

NAVAL POSTGRADUATE SCHOOL MONTEREY, CALIFORNIA



THESIS

**AN ENTERPRISE INFORMATION SYSTEM FOR
THE NAVAL SECURITY GROUP**

by

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March 1998

Thesis Advisor:

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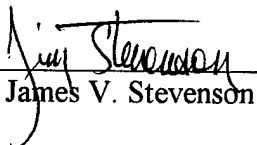
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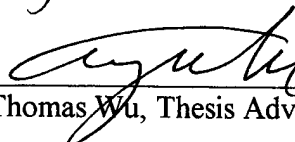
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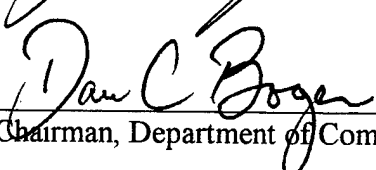
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ABSTRACT

U.S. Naval Security Group (NSG) community data resides in disassociated systems with no clear data hierarchy. The NSG's lack of a central information framework wastes money, consumes manpower, and underutilizes claimancy resources.

To improve NSG data operations, an Enterprise Information System (EIS) was designed and implemented using Commercial-Off-The-Shelf hardware and software. First, an Internet browser-based, client-server architecture was selected that optimizes performance, interoperability, and cost. Next, a database schema was designed and instantiated using relational technology. Then, web server database access files were created that emphasize connectivity and utility. Finally, EIS integrity and privacy concerns were examined.

The prototype NSG EIS optimizes personnel and resources, improves data accuracy and timeliness, and enhances the Naval Security Group's aggressive pursuit of information dominance. The proposed EIS provides the NSG with an affordable and efficient method for bringing timely and accurate information to bear in an increasingly information dependent military.

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I. INTRODUCTION

A. BACKGROUND

The United States Naval Security Group (NSG) is a large organization within the Department of the Navy (DoN) managing global assets and responsibilities. The NSG possess no clearly stated architecture for retention, forwarding, and processing of most administrative and operational data. Database administration and archival criteria remain undefined for individual commands and for the claimancy as a whole. This lack of information infrastructure and hierarchy wastes money and manpower. Furthermore, considerable confusion and frustration is experienced among members of the NSG community who lack the resources and guidance to meet ad hoc information requests.

In addition, the paucity of organized databases hinders the community's ability to perform time-based trend analysis. This inability prevents optimization of dwindling monetary and personnel resources. Having timely and accurate information is a cornerstone for both modern military operations and 21st century management practices and has long since become a necessity for the NSG.

We define an enterprise information system as an intranet of shared data united by a single data hierarchy. Subscribers update and query data within a tailored system using specific computer interfaces. Such a system provides all entities within a community efficient access to current data for decision making. This helps to eliminate guesswork and encourages optimization of assets. There currently exists a permanent need for a reliable enterprise information system for the NSG.

B. OBJECTIVES OF THE RESEARCH

This thesis describes in detail a model enterprise information system for use within the NSG and outlines the system requirements and its basic operational features. The thesis emphasizes hardware and software requirements, construction, and maintenance. A working operational prototype has been created and is available for public access. The objective of this research is to provide a working prototype that can be used as a reference for constructing the actual system.

C. RESEARCH QUESTIONS

The primary research question is: What is the best way to implement an administrative enterprise information system for the NSG? The subsidiary questions are:

1. Which hardware and software supports the system best in terms of functional requirements, support, and cost?
2. Which data model and database schema should be used? Which best suits the existing chain-of-command within the NSG?
3. What are the benefits of such a system to the NSG?
4. How can the security and integrity of the data be assured?
5. What are some of the considerations in maintaining such a system?

D. SCOPE

The thrust of this thesis is to demonstrate that the implementation of an enterprise information system within the NSG is feasible, cost-effective, and will improve the operation of the entire organization. The first step is to compare the current information flow within the NSG community to that of the proposed system. The second step is to outline hardware, software, and implementation decisions and analyze these choices in

terms of functionality and cost-effectiveness. The third step is to prove the design of the data architecture and show how this implementation best fits the needs of the NSG. The fourth step is to show how to reasonably assure the security and integrity of the data within the system. Finally, a summary of lessons learned and recommended future work is provided.

E. LIMITATIONS

The potential numbers of hardware and software implementation options available are too numerous for the scope of this thesis. For this reason, system requirements are based on compatibility with Microsoft Windows NT according to Department of the Navy [Ref. 1] and Fleet Commanders [Ref. 2]. Budgetary constraints within both the Naval Postgraduate School Computer Science Department and the NSG remain a limiting factor in the design of the system.

No consideration was made for inclusion of all functional groups within the NSG. A representative sample of the most prominent administrative and operational functions was chosen for conceptual use within this database system. This scoping was imposed due solely to the time requirements of coding an all-inclusive application. This limitation of functional areas does not reflect a deficiency in the capabilities of the hardware or software.

In addition, the data used to populate the database itself is not historical. Every effort was made to use data that closely simulates daily operations within the NSG. Further, the processing of classified data was not considered, as the Internet is the primary means of data communication on this system. The migration of this system to a

secure intranet would allow for the processing of secure information within this same data framework. More is discussed about this matter in Chapter VIII.

F. ORGANIZATION OF THESIS

Chapter I outlines the objectives, scope, limitations, and research questions of the thesis. Chapter II introduces the reader to the NSG and examines the community's current methods of information storage and retrieval. The intent is to construct a baseline for comparison to the proposed system. Chapter III acquaints the reader with the basics of data engineering, relational databases, and client-server computing. In addition, this chapter provides a justification for the selection of the information framework used in the proposed system. It details the benefits of implementing the proposed system from the viewpoints of NSG headquarters, its unit commanders, and the individual. Chapter IV examines hardware, software, and implementation decisions and describes the physical layout and basic utilization of each of the selected components. Additionally, this chapter details how a user's data requests and updates are translated and processed by the system and how these system components cooperate to ensure accurate information retrieval. Chapter V provides a detailed examination of the database schema and shows the interrelations among the tables, fields, and data. Chapter VI examines the capabilities of the sample site to include navigation through the site, data input, and data queries. Chapter VII examines methods for keeping the data uncorrupted and disclosing only appropriate data to appropriate individuals. Chapter VIII includes a summary of lessons learned and recommends further research topics on for this system.

II. THE NAVAL SECURITY GROUP

A. INTRODUCTION

To fully realize the benefits of implementing an enterprise information system, one must understand the enterprise itself. The NSG is assigned Department of the Navy-wide responsibilities for cryptology and Information Warfare/Command and Control Warfare by the Chief of Naval Operations [Refs. 3, 4, and 5]. The NSG is composed of over 11,000 officer and enlisted personnel stationed within the United States and its territories as well as numerous foreign countries.

The organization's headquarters directorate manages personnel in six specialized technical groups permanently and temporarily assigned to land-based sites, ships, submarines, and aircraft. NSG commands and units are divided into separate departments and divisions, many of which possess a large body of personnel and equipment available for extended and short-notice temporary assigned duty. Most often personnel are deployed to commands not assigned to the NSG command infrastructure. Maintenance of such constantly moving assets presents a formidable task.

Like most large DoD organizations, the NSG possesses a formal chain-of-command. Individual commands report directly to intermediate authorities. These commands, in turn, report to the headquarters unit. Units composed of NSG personnel temporarily assigned to non-NSG units use a temporary chain-of-command for data forwarding and submit duplicates of necessary data to certain NSG command elements. Since not all commands perform exactly the same function, each command's make-up

and structure is unique. The primary functional departments within a typical NSG command are:

1. Administration
2. Budget and Supply
3. Maintenance
4. Operations
5. Training

Any proposed enterprise information system must reflect only simple variations from this basic command organization.

B. PRESENT NSG DATA ARCHITECTURE

The NSG currently possesses no common means to store and retrieve data. Some information (particularly fiscal and personnel data) must be retained and forwarded to higher echelons at periodic intervals according to DoN guidelines. In other cases, individual units are tasked with maintaining databases according only to locally defined needs. With irregular guidance from overseeing organizations, individual units rarely know what data to maintain or for how long. Each unit operates independently with respect to gathering and archiving operational and administrative data. Most command-level database design and programming needs are accomplished by well-meaning, self-trained personnel with informal computer and database backgrounds. In the best case, the experienced and conscientious commander with intelligent and motivated personnel successfully anticipates chain-of-command requests for information. The worst and most common cases are sudden and large requests for data that has never been organized or

retained in any local database. A data request from a command entity will fall into one of the three following categories:

1. The data was not previously identified for retention by the local command or the headquarters unit. In such cases, the data must be obtained from non-automated files. Such scenarios are usually deadline driven and result in manpower intensive searches. Due to the lack of time and lack of commonality between file systems, the integrity of the data returned to the requesting unit is often questionable.
2. The data was previously identified for retention but the method of storage was not specified. In such cases, the data must be converted by the individual unit (or requesting unit upon receipt) into the desired format, forwarded to the requesting unit, and introduced into a new database system. This results in wasted effort, conversion problems with mismatched data types caused by the use of differing database management systems (DBMS), the added expense of conversion software and the manual reentry of the same data into systems.
3. The data was previously identified for retention and the DBMS was the same for both units. In such cases, the data must be delivered to the requesting unit by courier or electronic mail and then introduced into the requesting unit's system.

Regardless of the category into which an individual data request falls, once the data has been submitted to higher authority, individual commands have no means of

accessing community information as a whole. As such, many NSG individuals cannot view community data that would benefit local operations.

Furthermore, data is not archived for consistent periods at individual commands. New executive personnel and system administrators (SA) bring new data perspectives to an individual unit. As such, no consistent performance timelines are available for any units.

III. THE ENTERPRISE INFORMATION SYSTEM

A. DATABASES, THE RELATIONAL MODEL, AND SQL

A database is defined as a collection of related data [Ref. 6]. Databases may or may not be automated based on the desires, needs, and resources available to the user. For automated systems, there are numerous commercially available DBMS products from various vendors that organize data on magnetic media using many data schemes.

The most mature database technologies rely on a database model known as the relational model. In this model, a table of data values is created and specific data is organized into sets of data labeled by field names. Unique values, identified as keys, are used to distinguish particular data value combinations or tuples. Each table is then related to one or more other tables based on the relationships between these keys and the other data fields contained within the table. When a user queries (or updates) a database, a unique tuple or set of tuples is returned (or inserted into) one or more tables based on the user's request and the relationship of the tables.

A database language known as Standard Query Language (SQL) was designed to manipulate both the data and data organization of a database [Ref. 7]. SQL is based on mathematical principles and has undergone many revisions over the years. Many civilian corporations have been operating SQL-based relational database systems for years. The irreplaceable nature of the accumulated data to these users and the proven nature of the relational schema ensure that relational databases will continue to be a foundation of database systems even as new database systems are developed for the future.

B. DATABASE ARCHITECTURE MODELS

Database technology has been enriched by the unparalleled growth of computer development in the last few decades. The faster, more capable, and less expensive computer has enabled very large, very fast, sophisticated multimedia databases with remote access. The maturation of data technology has spurred the declining cost and rising availability of database systems.

The growth of computer communications and network computing has enabled computers to accurately transmit and receive large quantities of digital data very rapidly. To take advantage of this technology, database engineers have devised architectures that allow the networking of databases together.

The manner in which databases are joined together to achieve a coherent data picture is known as a database architecture. There are currently three basic database architectures commonly in use today.

1. Stand-Alone

In this model, a database is instantiated, operated, and maintained on a single machine that does not communicate with any other to maintain this data. A typical example is one's personal computer where financial records are kept.

Most available DBMS software is intended for operation in this mode. The primary drawback to this type of system is that users in differing locales do not have simultaneous access to this data. Although some of these systems are being expanded for use in Local Area Networks (LAN), a user must still be physically present at the computer (or LAN) that contains the database in order to manipulate the data. Numerous

examples of these types of databases exist in NSG using such varied DBMS software as Borland's Paradox, Microsoft's Access, and Oracle's Oracle 7.

2. Distributed

In this model, different types of such locally maintained databases are linked together over some common network. An additional set of hardware and software provides translation and communication services between the differing DBMS products and database designs. In a typical large distributed database system, a search engine queries numerous databases. The appropriate server(s) returns the desired response based on input from the user. The main drawbacks to this type of system are their complexity, maintenance overhead (individual units are responsible for keeping their systems and data up to date), cost, and performance. Anyone who has used a search engine to recover information from the worldwide web has used a distributed database system.

3. Client-Server

The client-server model utilizes elements of both the stand-alone and distributed models. In client-server computing, data processing responsibilities are divided between the computer that wants a certain service performed (the client) and the computer that will attempt to provide that service (the server). An interface between the client and server makes the system user-friendly.

The client and server computers are not required to be co-located but may be distantly connected by a communications network. In client-server database systems, only the database server(s) contains the DBMS and the database data. Any number of clients may query and update the database. The performance of the system is limited by the capabilities of the client, the server, and the network itself. The main drawback of the

client-server database architecture is that a great deal of planning must go into the system before it can be properly implemented. In addition, the client-server database must be flexible enough to account for future data processing and retention needs.

Figure 1 shows a comparison of the major advantages and disadvantages of these three types of database architectures.

	Stand-Alone	Distributed	Client-Server
Cost	Low	High	Medium
Data Accessibility	Low	High	High
Implementation Effort	Low	High	Medium
Performance	High	Medium	Medium
Scalability	Low	Medium	High
Security & Data Integrity	High	Low	Medium
Upkeep & System Administration	Low	High	Low

Figure 1. Advantages and Disadvantages of Various Database Architectures

C. SELECTING A DATA MODEL FOR THE NSG

1. Criteria

The competitive nature of the computer industry continues to drive dramatic improvement in both computer hardware and software. These leaps in performance and

capability are occurring over very short periods of time at minimal cost to the consumer. In today's market, few can afford to be constrained by the old "maintain and upgrade" strategy. It is far cheaper to purchase a newer and more capable system than it is to upgrade an old one.

Faced with shrinking force structures and budgets, the DoN now encourages maximal use of such Commercial-Off-the-Shelf (COTS) equipment due to this low cost and relatively short development pipeline [Ref. 8]. The old monolithic military acquisition system and stringent system of specifications for defense systems (MILSPEC) have been reduced or even eliminated in most cases. It is true that there remain some marked differences between the requirements of civilian and military computer database systems [Ref. 9], most notably with respect to redundancy and survivability. However, in today's environment, a degree of flexibility has been granted to community leaders to define their data processing requirements and seek the appropriate computer solutions.

For the NSG, a fully implemented community-wide database system must meet many additional requirements. These requirements are stated in Figure 2. Meeting these stipulations would ensure that the appropriate database system could be realistically fielded in minimal time and at reasonable cost and effort to the community.

Accessible	All sites should possess the capability to update and query selective portions of the database.
Compatible with existing legacy databases	NSG possesses large quantities of disconnected data on older relational systems. The system must be capable of incorporating this data as necessary.
Compatible with existing operating systems	Microsoft NT is the most commonly available computer operating system. Use of NT ensures compatibility with existing systems and easy upgrades.
Easy for the novice to operate	Not everyone knows (or even likes) computers. The system should not require additional training for the common user to operate.
Flexible	Large communities are dynamic and change administrative and operational requirements over time. The database should be flexible enough to change without losing historical data.
Inexpensive	The initial cost should not be a prohibitive factor in implementing the system. Field sites should not have to purchase new software to operate the system.
PC Based	A PC based system ensures that there is no large infrastructure to maintain or expensive upkeep cycles. NSG personnel continue to be trained in basic maintenance of PC based systems.
Scalable	The system should be quickly and affordably upgraded (or replaced) when it becomes too slow or lacks sufficient capability.

Figure 2. NSG EIS System Requirements

2. Selection

Based on the above stated criteria, the most logical choice of database models and architectures to suit NSG needs is the relational database model implemented with the client-server architecture. This selection, known as an enterprise information system (EIS), optimizes the existing NSG hardware and software inventory without requiring changes in the basic chain-of-command organization.

There are numerous relational database systems available to the user for operation within a client-server environment. In order to meet the compatibility, cost, and ease of operation benchmarks, one stable software suite should be chosen.

The Microsoft Corporation offers packaged software subscriptions that include comprehensive software upgrades at no additional cost as well as free technical support. The most practical of these solutions, the Microsoft Developer Network (Universal Subscription), is available for an annual fee and contains all of the software necessary to construct and implement an EIS that meets (and exceeds in some cases) the stated criteria. The principal elements of this package are the server operating system (NT version 4.0), the web server (Internet Information Server 3.0), and the database server (SQL Server 6.5).

D. BENEFITS GAINED BY EIS IMPLEMENTATION

An EIS would greatly benefit the operations of the NSG. The principle benefits gained by using the EIS architecture are described below. A comparison to the existing NSG data structure is also provided.

1. Increased Functionality

a. Capacity

The proposed EIS database capacity is limited only to the size of the server hard drive. SQL server does not limit the number of independent databases that may exist on the server. The data capacity of the existing NSG data architecture is difficult to determine because the same data is not kept from command to command. Based on the size of the example database site discussed later in Chapter VI, an 11,000 member NSG would conservatively need 50 gigabytes of storage capacity per year.

b. Connectivity

The proposed EIS allows every unit to be connected to a central database through the Internet (or any community wide intranet). The Microsoft database server allows in excess of 32,000 simultaneous networked connections.

Under the present system, there is no way to access all of the community's data at once. The existing structure limits the ability of one command to compare its data to another. It is very difficult to view NSG operations as a whole.

c. Data Accuracy

Currently, individual command databases, even ones that are standardized between separate units, cannot be updated at the same time. NSG units are located in differing time zones and use different update intervals. Such activity prohibits accurate data interpretation by command entities. With the EIS, an update occurs as soon as an individual enters data into the central database.

d. Data Interpretation

There is now no systematic way to gauge the accuracy of the data passed along the chain-of-command. Data reporting guidelines may be interpreted differently by different individuals. The standardized interfaces of the EIS will help to resolve the conflicts of how to interpret data from various sources. The interface can be pre-programmed to accept data only in certain ranges or at certain times. Data that does not meet the guidelines is rejected. This helps to ensure the database remains accurate.

e. Historical Data Comparison

An EIS allows automatic dating of information stored in the database. Provided that the database schema implementation does not overwrite data, all data can

be analyzed with reference to the time an action occurred. Most NSG historical data comparisons are currently performed manually.

f. Informed Decision Making

High level decision making scenarios usually arise unexpectedly. Most often in today's workplace, managers do not have all the information they need to make qualified decisions. The EIS allows appropriate information to be instantaneously and continuously available to all levels of management.

Additionally, under current NSG reporting policies, periodic (weekly, monthly, quarterly, and annually) reports from subordinate commands to higher echelon authorities are the standard. When this information is archived, only these milestones are available for view. Using the EIS, these guideposts are expanded. All information is available all the time. Decisions may thus be data driven instead of impromptu.

g. Timeliness

Currently, many important decisions (budget, operations, personnel matters, etc.) are often delayed because all outlying commands cannot gather and submit required information in a timely manner. These occurrences are rarely the fault of the individual unit. Such situations arise because the current system relies on manual transfer of paper or magnetic media that are subject to a number of factors outside the control of the individual unit. Under the EIS, the timeliness of an update is limited only by the status of the computer equipment. As long as units make inputs as appropriate data arrives, the results of a query are always current.

2. Optimized Use of Personnel

a. Database Consistency

The current system requires many people at many sites to maintain data consistency. Each site usually has a different set of relational tables located on a different computer with a different DBMS. When data is forwarded to command authorities, a team at each command site is required to manually combine the polled data into yet another database. This is accomplished by reformatting the data to fit the new structure or manually reentering the data. As an example, Pacific NSG commands currently submit TAD (temporary additional duty) expenditures by magnetic disk to the NSG element of CINCPACFLT (Commander-in-Chief) for reentry into a larger system.

This method is far too labor intensive and does not make maximum use of available technology. The EIS uses networking to make all updates automatically to the same database on the same server. Thus the database is always consistent and no database experts are required at the local or intermediate commands.

b. Database Design and Upkeep

A change in the NSG community currently requires a commensurate change to multiple databases and database formats throughout the claimancy. With the EIS, when a change in the community requires a change in the database, the database has to be changed only once at the server level. There is no longer a need to notify commands to change a certain field within a certain table or rely on the local command expert to understand the problem and implement an appropriate solution. One person at the headquarters level can make the change once for the entire community.

3. Reduced Training

Presently, people have to be trained to use a variety of different DBMS software. Users must learn a wide variety of technical skills to ensure proper maintenance (how to create and change the database) and use (how to enter data and make queries) of a DBMS. Because of numerous DBMS applications within the NSG non-standardized training practices are common.

The EIS uses Internet browser technology to update and retrieve data. Most computer users are familiar with how to use the World Wide Web. For those that are not, a browser is much easier to learn than how to operate any stand-alone DBMS. Implementing an EIS would require training of only the team at the headquarters unit that conducts maintenance and change to the server-based system.

Another problem that currently exists is that commands periodically lose their database experts due to normal military duty rotations. Most often, operations are hampered while another expert is found or trained. When all database design and update occurs at one central location, community planners can more easily maximize personnel resources, training, and plan for contingencies.

4. Reduced Cost

a. Initial Purchases

At the moment, implementing a new database requires a separate DBMS for each database that is to be created, as well as a computer (perhaps many) at each command. The cost of the Microsoft subscription is \$2499 annually [Ref. 10]. Currently the costs of DBMS site licenses alone far exceed this price tag. As an example, consider Borland's Paradox 7 for Windows, one of the most prominent stand-alone DBMS

products in use in the NSG. Purchasing one initial system (\$349.95) and four one-user site licenses (\$119.95) for only twenty sites would total \$16595 [Ref. 11]. This does not include the cost of upgrade packages or shipping and handling.

The only unique cost to the EIS is in the purchase of new hardware. Hardware specifications will be discussed in detail in Chapter IV. A suitable server with a back up would cost less than \$10,000 on the commercial market. The computers used at various commands solely for database applications could be freed to perform other functions.

Should the community wish to incorporate legacy data from older systems, the cost to do so within the existing framework would be prohibitively expensive. With the EIS, this data insertion would only need to be done once instead of once for each pertinent database at a command site. The selected database server, SQL Sever 6.5, is capable of being easily uploaded with data from most existing DBMS software, including non-Microsoft products.

b. Ongoing Maintenance

Upgrades to the DMBS software at commands can be very expensive and often cost as much as the original investment. Vendors often distribute upgrades and technical support using costly maintenance packages. Using Microsoft's subscription option, software upgrades are mailed directly to the database server site as soon as they are publicly available.

Additional costs are incurred when consulting services are reserved. Currently each of the different DBMS software systems requires different vendor services. The Microsoft universal subscription contains limited free technical support

and permissions within a developer's network that lends assistance with technical issues. No vendor calls were necessary during the construction of this model due to the abundance of available reference material and on-line help.

The cost of the couriers and mail services required to transport information from local databases to headquarters managers under the current system is also noteworthy. Using the EIS model, updates and queries are conducted over the Internet, which does not even incur the cost of a long-distance phone call.

IV. IMPLEMENTATION

A. SYSTEM DESIGN

1. Physical Layout

An EIS database must reside on a server that is electronically accessible to everyone in the community. Many of the networks commonly in use in the NSG have stringent security features that make them inaccessible to most computers at the Naval Postgraduate School. Since the Internet is the most universal and least restrictive network available, it was chosen for this research.

Theoretically, the server and all its components could be based at any NSG site. The most practical location is the NSG headquarters element. There are several reasons for this:

1. The NSG headquarters element is located inside the continental United States. Access to dependable communication facilities is a necessity for a reliable system. Major headquarters sites tend to have an abundance of telephone capacity.
2. NSG Headquarters is the site where community policy is formulated and promulgated. Any policy change requiring a change in the database structure could be more quickly and easily accomplished by maintenance personnel if the server is closer to the decision making process.
3. NSG Headquarters already has a functional Internet web site. Proven connections would make installation and maintenance far simpler.

Thus, through the Internet, all NSG sites with a computer, a connection, and a web browser are now capable of Internet connection to the NSG server. Figure 3 is

provided to compare the basic physical communication layout of the EIS to the NSG command framework. Solid lines represent the formal chain-of-command structure while dashed lines represent information flow.

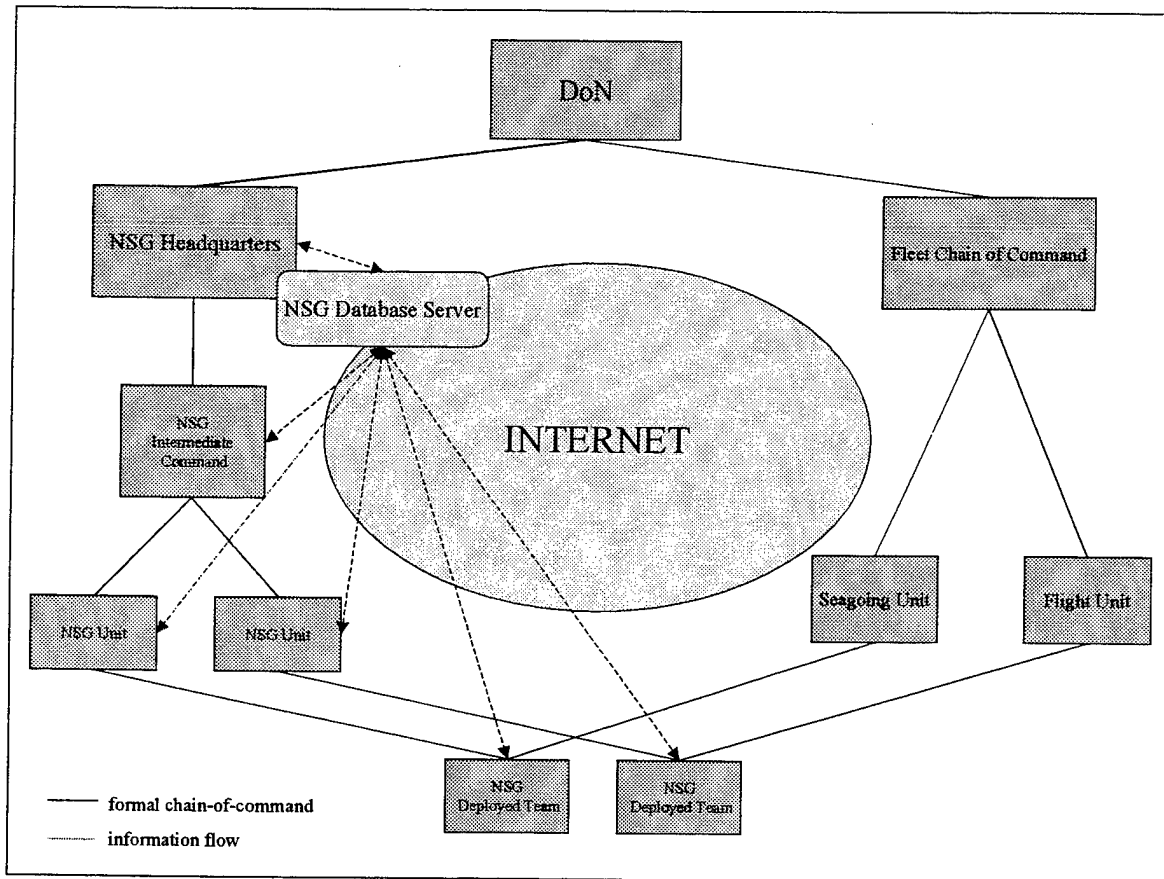


Figure 3. Physical Layout of the NSG EIS

2. Operation

The operation of the system is designed around the chain-of-command that is currently in place in the NSG. Presently, individual NSG commands collect data for submission in the form of daily reports. This data is retained in hard-copy files and stand-alone databases or simply discarded.

The focus of the EIS is not to change a command's reporting responsibility but to make the manner in which these actions are carried out more efficient. Instead of

gathering data, manually performing calculations on this data, and then combining all of this into a report, the operator uses the EIS.

The user logs onto the system, then locates, completes, and submits the appropriate data using an input form. This process updates the EIS data. The EIS contains preprogrammed query routines that are available for a number of common reports. The operator may select such a report at any time. The EIS performs the calculations for the operator. This ensures that the calculations are done correctly and in a uniform manner from command to command. Additionally, the data is permanently archived in the central repository. Hard-copy reports can be printed from the browser if desired.

Individual units are still accountable for their specific areas of responsibility. EIS operation allows commands to preserve their uniqueness and autonomous nature. Since people need not be trained extensively on how to operate a web browser and their reporting responsibilities are unchanged, minimal interruption is expected when bringing the EIS on-line.

3. Information Flow

When one uses a web browser to connect to the EIS, one types in the Universal Resource Locator (URL) or the Internet Protocol (IP) address into the browser URL box. Once the correct address is submitted, the client machine has the necessary information for connection to the server. Figure 4 shows the path the user takes in order to reach the data in the EIS database. It is important to remember that connection to a server does not necessarily imply access to the database. Selective access to the data for security and data integrity reasons is covered in more detail in Chapter VI.

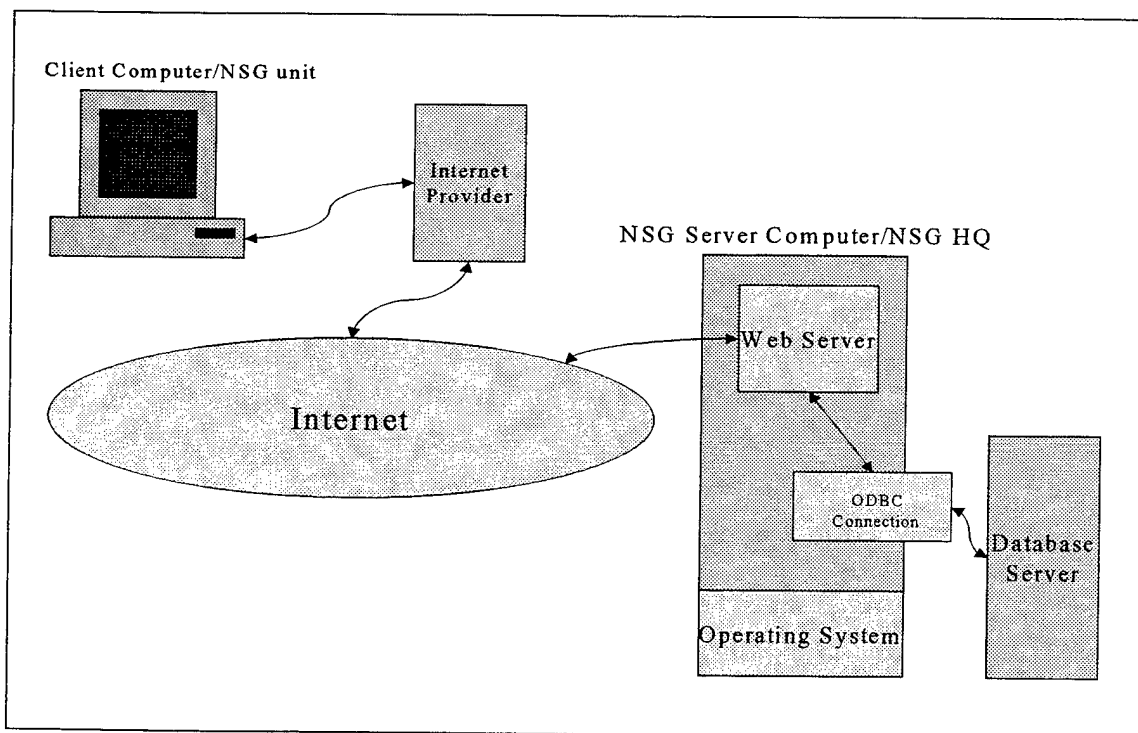


Figure 4. Client Server Information Flow

The machine address is passed to an Internet provider (the DoD uses its own hubs rather than use commercial providers) which searches for the server URL address on the Internet. Once the correct server is located, a connection is established so that the two machines may exchange information. The EIS web server application, Microsoft's Internet Information Server (IIS), makes an initial web page accessible to the client. The user is allowed access when a given password returns a positive match when compared to a corresponding table in the operating system files.

The first page EIS displays server as a kind of directory page. The user may navigate through any subsequently linked pages to which they are granted access. Web pages are linked together using a protocol known as hypertext transfer protocol (HTTP). The address of the next page is submitted to IIS when the user click an object and IIS fetches it or transfers control to another web server if it does not control this page.

EIS web pages are designed to allow the user to insert, update, or query a database. To do so, the web server must connect to the database server. IIS uses a pre-configured application programming interface known as Open Database Connectivity (ODBC) that tells IIS the server name, the database name and the criteria with which to connect in order to satisfy the client's request. An ODBC path name is required in each query or update file on the EIS server. It is specified and controlled through the server operating system and is not directly supplied by the user.

The system is now ready to access the database server. The database can be accessed with (an update or a query that prompts data from the user) or without user input (a standardized query routine). The following steps, graphically displayed in Figure 5, must occur in order for the client to access the database:

1. The client clicks on the desired page. This brings up a web page known as a hypertext mark-up file (HTM).
2. This file may reference another HTM that contains a format for the user to perform input. This step is omitted when user input is not required. A sample HTM file is located in Appendix C.
3. The HTM calls an Internet Database Connector (IDC) file, which contains the ODBC path name, additional connection parameters, and SQL code. The IDC communicates to the database server which database to use and what data should be retrieved (or updated). The SQL code outlines the specifications of the query. A sample IDC file is contained in Appendix C.

4. The database server performs any calculations and returns the data to IIS. The IDC file contains a reference to another file called a hypertext markup template file (HTX). The HTX serves as a place to put the data once the query has been completed. The HTX is configured to present the data in any fashion the programmer/administrator deems suitable. A sample HTX file is contained in Appendix C.
5. IIS then presents the HTX with the data to the client for the user to view.

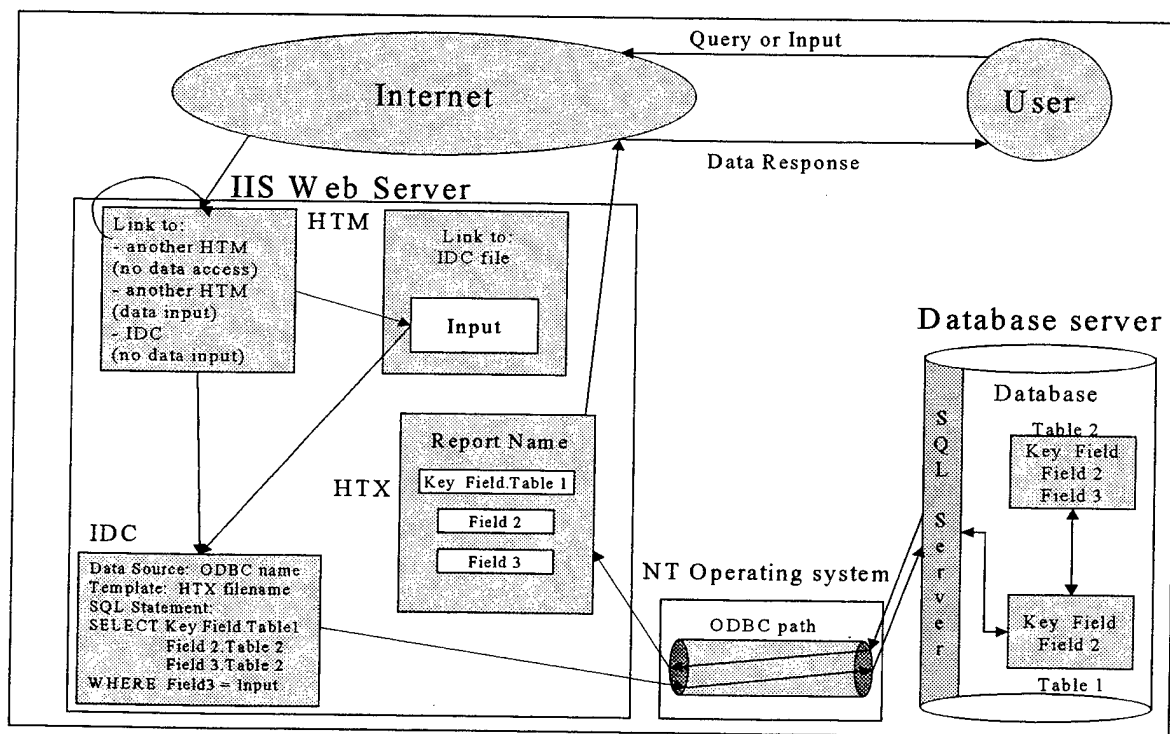


Figure 5. EIS File Interaction

After this process is completed, the user can select any other HTM displayed in the HTX (another link) or use the browser tools (back, forward, home, etc.) to navigate through EIS.

The server operating system maintains all of the IDC, HTM and HTX file structures and monitors all aspects of each transaction in order to ensure proper operation

throughout the time a client is active. The web server manages the user's connection to the server and presents the correct web pages as selected by the user. The database server is responsible for reading SQL statements and performing appropriate operation. The next section describes the necessary hardware and software required to construct the EIS using this hierarchy.

B. SERVER REQUIREMENTS

1. Hardware

Theoretically, any computer with a network card and cabling can function as a server. Due to the amount of processing a server must conduct and the number of connections it might have to maintain, the high-end server is faster and possesses more capacity than the standard personal computer. Generally, a more powerful processor and more Random Access Memory (RAM) lead to a more efficient system. Microsoft recommends [Ref. 12] that any server that runs NT 4.0 as an operating system possess at a minimum:

1. A 90 megahertz (MHz) Intel Pentium processor
2. 64 megabytes (MB) RAM

A 90 MHz processor is no longer commercially available and is not sufficient for serving many. A database server with at least Pentium II technology (233 MHz) capability is recommended. Servers that contain multiple processors would be optimal for this system. Dual processor servers are now commercially available for approximately \$5000.

The EIS server needs a large hard drive to hold all of the server software packages, the application software, and a number of file creation tools (discussed in detail later in this chapter). It also needs sufficient space to store the large number of HTM, HTX, and IDC files that the client may access. A hard drive with at least 100 gigabytes (GB) of active storage is recommended.

To construct the sample EIS site, the prototype EIS server was constructed using a DELL Dimension XPS Pro 200 personal computer. The system is based on a 200 MHz Intel Pentium microprocessor and contains 64 MB of RAM. The server has 5.96 GB of hard drive space divided between two drives. It is fitted with a 3Com 3C59x Etherlink III Bus Master Network card for server connection to the Naval Postgraduate School hub.

For storage, the system has one 3 1/2 inch floppy drive, an Iomega ZIP drive for 100 MB cartridges, and an Iomega JAZ drive for 1 GB cartridges. Additionally, the system has one 12X CD read only device.

2. Software

a. Server Operating System

The server operates using Microsoft NT Version 4.0 as implemented through the Microsoft BackOffice 2.0 suite. With additional network cards, NT is capable of supporting other computers in a LAN configuration. An NSG headquartered EIS would require this LAN option in order to share the maintenance workload among a database administration team. A LAN was not utilized on the prototype.

NT set-up is easily accomplished using an install wizard. The wizard prompts the user for information at each step in the installation process. Since the NSG already possesses Internet provider services, the installer only needs a name and IP

address for the EIS server and an IP address of the Internet provider for routing purposes. NT does not need any special configuration for the EIS to function properly. If the server has enough hard drive space, a full load of the operating system is recommended.

b. Web Sever

The web server, Microsoft IIS version 3.0, is loaded in conjunction with the NT BackOffice suite. IIS 3.0 has since been replaced by version 4.0. IIS also uses an installation wizard and is pre-configured to begin running automatically each time the server is rebooted.

IIS contains many sample web pages that load upon initial installation. The server defaults to the web page `InetPub/wwwroot/default.htm` as its root page. Thus, if the default is not reconfigured, a client who connects to the server will see this default web page and will be able to navigate only within Microsoft's sample site. The simplest way to change this is to replace this default file with a new page. If this file is named `default.htm`, subdirectories and links to other pages in separate directories can be inserted to direct the client to new areas within the EIS without extensive file modification.

To create or modify HTM or HTX files (the files seen by the user as web pages), a web editor such as Microsoft Front Page 98 must be used. There are many good references available for web site design and creation. It is most important to devise a good file structure naming convention to avoid confusion. An EIS requires a large number of web pages to effectively serve a client.

Since each IDC file contains SQL code, a text editor such as Microsoft Word 97 is also required. An explanation of SQL statement syntax is beyond the scope of this thesis. Again, there is a great deal of published material available on the topic of

SQL and manipulating database fields. As with the HTM and HTX files, a greater number of IDC files provides a finer granularity for interaction between user and database. Approximately 350 separate IDC, HTM, and HTX files were used in the creation of the prototype site. Fielding an actual site with increased functionality would require many more.

c. Database Server

The heart of the EIS is the database server. The database structure and data reside in this portion of the system. Although in this project, the database server and the web server were both physically present on the same machine, the ODBC can just as easily connect IIS to a database server that is located on a separate computer.

Microsoft SQL Server 6.5 is

A relational database that's capable of handling large amounts of data and many concurrent users while preserving data integrity and providing many advanced administration and data distribution capabilities. [Ref. 13]

Like NT and IIS, it is loaded from the BackOffice suite through a wizard and requires no special configuration.

Database systems, including this EIS, need a database administrator (DBA) to monitor the database. They are charged with keeping the file structure current, managing access and user accounts, and optimizing database performance. SQL Server 6.5 offers a menu of powerful service managers for the DBA to use to accomplish these tasks. The most important of these service managers and their functions are listed in Figure 6.

Service Name	Function
Enterprise Manager	Allows the DBA to create, destroy, manipulate, backup, and replicate databases.
Performance Manger	Allows the DBA to monitor the system usage and execution.
Security Manager	Allows the DBA granular control access to individual databases.
Service Manager	Allows the DBA to control operation of the database server.
Web Assistant	Gives the DBA a tool for quick and easy creation of database routines that will run on the operating system.

Figure 6. Primary SQL Server 6.5 Service Managers

In order to create a database using SQL Server 6.5, a database device must first be created. This device will partition SQL Server utilities and memory into distinct areas so that each database can be independent from the next. Using the Enterprise Manager, select *manage database devices* to create a device. There are several devices that are already loaded when SQL Server 6.5 is initially loaded. These devices contain databases to serve as file templates that the system uses in its operations. These should not be modified.

A device is divided into a log portion and a data portion. The log portion holds the physical structure (tables, query and update routines, etc.) while the data section holds only the database data itself. The amount of memory assigned to each of these portions is limited only by the amount of available memory on the database server hard drive. For this project, a 100 MB device was created with 20 MB allotted for the log device and 80 MB allotted for data.

The next step is to create a database to reside on that device. Using the Enterprise Manager, select *manage databases* to create a new database. The database server now recognizes the new database although it has no structure or data.

Next, the database must be supplied with a relational structure. The Enterprise Manager also contains tools for table creation and maintenance. Creating a table involves naming the table, dividing it into the desired fields, assigning data types to these fields, and then declaring the appropriate relationships between various tables through the *manage tables* icon. Only after a database schema has been assigned to a database may it be populated with data.

Unfortunately, SQL Server 6.5 is a back-end tool only. This means that another application (such as Microsoft Access or the IIS interface of the EIS) must be used in order to insert data into the database. There is no convenient way to directly enter data using SQL Server 6.5. Furthermore, the tools supplied with the Enterprise Manager to manipulate the structure of a database are useful when a database already exists but very cumbersome when used to create a new one.

Microsoft Access is a popular stand-alone relational DBMS in wide use throughout the NSG. The DoN and civilian corporations in past years have cached much valuable data using this DBMS. One of its best features is a wide variety of graphical tools that empower the database designer to easily construct a database. One does not need to be proficient at SQL in order to create the tables, queries and update routines required of a good database.

In order to provide the user a way to retain existing Access data and gain the increased availability, functionality, and security of SQL Server, Microsoft created a tool called Microsoft Upsize. Upsize copies any Access database and its data, and then converts it to SQL Server format. It then transfers this package directly to any available SQL Server database indicated by the user. Upsize supplies the capability to employ the

user-friendly tools of Access but retain the power of the SQL server. In addition, the NSG community can use Upsize to facilitate the entry of necessary legacy data into the EIS. Once installed, Upsize is implemented through the *tools* section in Access. Upsize can be downloaded at no cost (Microsoft Home Page).

d. ODBC Path

The final step in implementing the EIS is to establish the ODBC connection. Both IIS and Upsize require an ODBC path name in order to connect to SQL Server. The ODBC path is created using Windows NT utilities contained within the control panel. The SQL Server driver automatically loaded when NT version 4.0 is installed. It is important to identify the path name, the name of the server with which to connect, and the name of the desired server database when creating an ODBC path. Once instantiated, an ODBC path is a permanent reference until deleted.

C. CLIENT REQUIREMENTS

Any client machine with a modem or direct connection to an Internet provider is capable of connecting to the EIS server. No other hardware is required. The client must use a web browser to communicate with the database. Compatibility of Microsoft products between client and server is not necessary. Both Microsoft Internet Explorer and Netscape Navigator are prevalent throughout the NSG.

V. DATABASE SCHEMA

A. OVERVIEW

The essence of any relational database remains the number and type of fields contained within individual tables. Table fields provide a framework for the DBMS to know what data to store and how much memory to reserve for each field. A listing of the separate fields in each table of the database and the manner in which these are related to one other is known as the database schema. The database schema delineates how the data is to be preserved by the DBMS. A proper database schema provides the user a powerful framework within which to store and retrieve data in a logical and useful manner.

Each field in a table must be assigned to a specific data type. Data types allow the DBMS to optimize storage space by allocating a specific amount of memory for each field of data. Some data types even allow the database engineer to specify the maximum size of the field. This feature allows the database designer to improve memory availability and configure a system for maximum performance. The SQL server 6.5 data types used in the EIS database schema are:

1. *Datetime* - A block of integers consisting of a six-digit date followed by an eight-digit time
2. *Float* - A decimal point number
3. *Image* - An item that will be displayed as a picture
4. *Int* - Integers (no decimal point) only
5. *Money* - A number with two decimal places
6. *Text* - Characters only
7. *Varchar* - Any integer or character combination

In contrast to data types, database relationships show how data fields in one table are linked to other data fields in separate tables. Linked fields must always be of the same data type and size. A relationship constraint shows all possible combinations between any related fields. A relationship may be classified as one-to-one ($1 \rightarrow 1$) or one-to-many ($1 \rightarrow \infty$). In a one-to-one relationship, each field value is unique and may appear only once in each of the indicated tables. In a one-to-many relationship, the first field value may appear only once in the first table but the second may appear multiple times in the second table. A many-to-one ($\infty \rightarrow 1$) designation is identical to one-to many but in reverse order.

To simplify a relationship description in this chapter, the standard SQL "dot-notation" is used. In this nomenclature, the name of the desired table appears immediately before a period while the name of the indicated field is displayed after. Thus, "TableA.Field1" indicates Field 1 of Table A.

This EIS database schema consists of 33 distinct tables comprised of 253 fields and 68 separate relationships. For efficiency, each of these tables has been placed into one of the six basic functional groups depicted in Figure 7.

Each table has been assigned to a differing functional group in order to maximize personnel resources at individual commands. Though overlapping somewhat in functionality, each category group represents a separate NSG working specialty that is defined by a unique set of NSG data keeping operations. At NSG sites, individuals working in these sub-specialties have different ratings, have undergone different job training, and are usually grouped into separate departments and divisions with different chains-of-command.

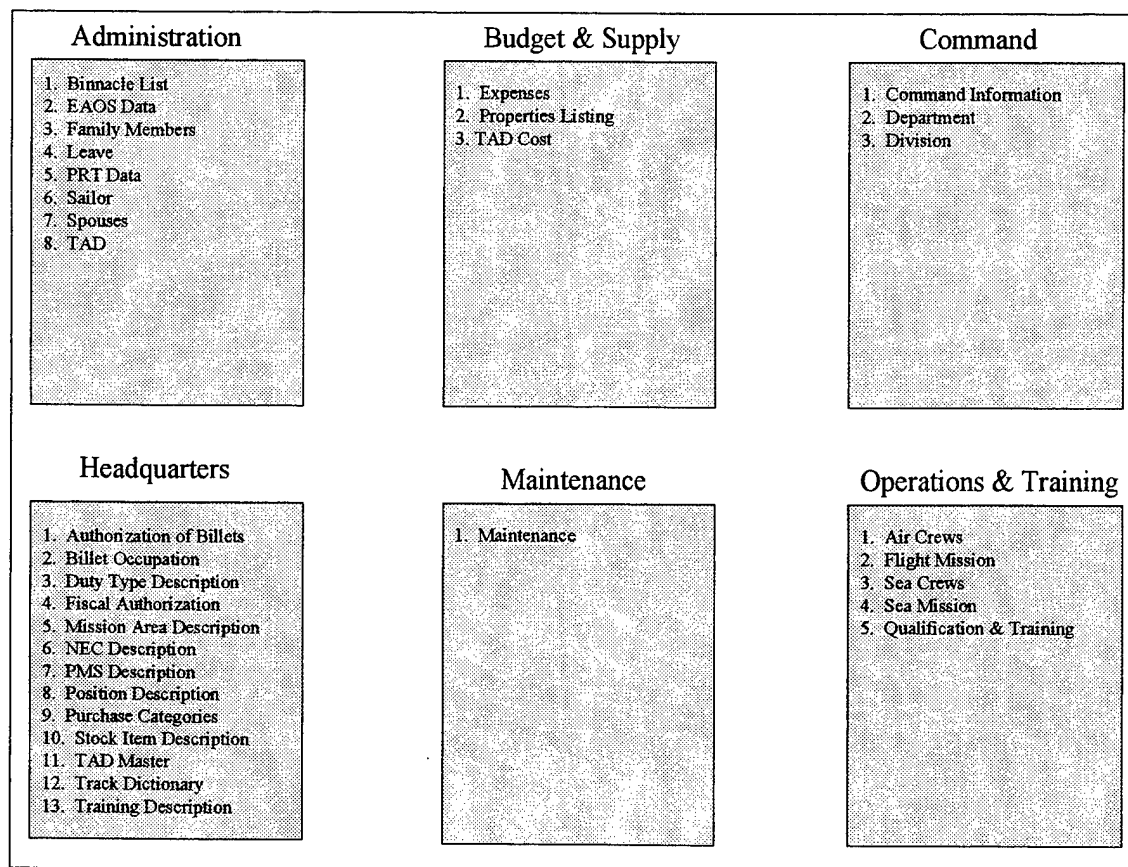


Figure 7. NSG Functional Groups and their EIS Tables

Each table is discussed individually in detail in the following section. A brief description of the group itself is first given followed by a schema for each table in the group. A brief description of the table's purpose is also provided followed by all of its fields, data types, relationships, and relationship constraints. Data type sizes for the varchar type have been omitted for clarity. All table names are given in italicized script while table key fields (if any) are listed in boldface. A blank space in the "links to" column indicates that a field has no direct correspondence to any other table field.

1. Administrative

The Administrative element of a NSG command performs all unit level clerical duties. Its primary function is to process and maintain personal and military information about each command member and their families.

Typical tasks assigned to this group include generating travel orders, maintaining personnel records on job performance and occupational specialties, maintaining statistics on temporary duty assignments and days worked, processing incoming and outgoing command personnel, and maintaining command directories. Eight EIS basic tables have been constructed to contain the data generated by the administrative functional group in the sample EIS. Each is described in Figure 8.

<i>Table and Purpose</i>	<i>Field Name</i>	<i>Type</i>	<i>Links to:</i>	<i>Type</i>
<i>Binnacle List</i> Duty absences due to illness or injury	Command ID	Varchar	Command Information.Command ID	$\infty \rightarrow 1$
	Control Number	Varchar		
	End Date	Datetime		
	Social Security Number	Varchar	Sailor.Social Security Number	$\infty \rightarrow 1$
	Start Date	Datetime		
<i>EAOS Data</i> Individual End of Active Obligated Service dates	Departed Service	Datetime		
	Reenlistment Date	Datetime		
	Reenlistment Period	Int		
	Retired	Datetime		
	Social Security Number	Varchar	Sailor.Social Security Number	$\infty \rightarrow 1$
<i>Family Members</i> Command family member data	Birthdate	Datetime		
	Family Member Social Security	Varchar		
	Name	Varchar		
	Sailor Social Security Number	Varchar	Sailor.Social Security Number	$\infty \rightarrow 1$
	Sex	Varchar		
<i>Leave</i> Duty absence due to vacation	Command ID	Varchar	Command Information.Command ID	$\infty \rightarrow 1$
	Date of Departure	Datetime		
	Date of Return	Datetime		
	Leave Control Number	Varchar		
	Social Security Number	Varchar	Sailor.Social Security Number	$\infty \rightarrow 1$
	Type of Leave	Varchar		
<i>PRT Data</i> Individual scores on the semi-annual Navy Physical Readiness Test	Command ID	Varchar	Command Information.Command ID	$\infty \rightarrow 1$
	Height	Varchar		
	PRT Date	Datetime		
	PRT Identifier	Varchar		
	Pushups	Varchar		
	Run Time	Varchar		
	Situps	Varchar		
	Social Security Number	Varchar	Sailor.Social Security Number	$\infty \rightarrow 1$
	Status	Varchar		
	Weight	Varchar		

Figure 8. Administrative Group Tables

<i>Table and Purpose</i>	<i>Field Name</i>	<i>Type</i>	<i>Links to:</i>	<i>Type</i>
<i>Sailor</i> Personal data about command members	Address	Varchar		
	Birthdate	Datetime		
	City	Varchar		
	Country	Varchar		
	Date of Rank	Datetime		
	First Name	Varchar		
	Homephone	Varchar		
	Homestate	Varchar		
	Hometown	Varchar		
	Last Name	Varchar		
	Last Updated	Datetime		
	Middle Name	Varchar		
	Paygrade	Varchar		
	Photograph	Image		
	Postal Code	Varchar		
	Primary NEC/Designator	Varchar	NEC Description.NEC Designator	$\infty \rightarrow 1$
	Rank/Rate	Varchar		
	Secondary NEC	Varchar	NEC Description.NEC Designator	$\infty \rightarrow 1$
	Service Entry Date	Datetime		
	Sex	Varchar		
	Social Security Number	Varchar	Air Crews.Social Security Number	$1 \rightarrow \infty$
			Billet Occupation.Social Security Number	$1 \rightarrow \infty$
			Binnacle List.Social Security Number	$1 \rightarrow \infty$
			Department.Department Chief SSN	$1 \rightarrow \infty$
			Department.Department Head SSN	$1 \rightarrow \infty$
			Division.Division Chief SSN	$1 \rightarrow \infty$
			Division.Division Officer SSN	$1 \rightarrow \infty$
			EAOS Data.Social Security Number	$1 \rightarrow \infty$
			Expenses.Purchaser SSN	$1 \rightarrow \infty$
			Family Members.Sailor Social Security Number	$1 \rightarrow \infty$
			Leave.Social Security Number	$1 \rightarrow \infty$
			Maintenance.Person	$1 \rightarrow \infty$
			Properties Listing.Inventory	$1 \rightarrow \infty$
			Properties Listing.Purchaser	$1 \rightarrow \infty$
			Properties Listing.Subcustodied	$1 \rightarrow \infty$
			PRT Data.Social Security Number	$1 \rightarrow \infty$
			Qualification and Training.Sailor Social Security Number	$1 \rightarrow \infty$
			Sea Crews.Social Security Number	$1 \rightarrow \infty$
			Spouses.Sailor Social Security Number	$1 \rightarrow 1$
			TAD.Member Social Security Number	$1 \rightarrow \infty$
	State or Province	Varchar		
	Tertiary NEC	Varchar	NEC Description.NEC Designator	$\infty \rightarrow 1$
	Warfare Device 1	Varchar		
	Warfare Device 2	Varchar		
	Warfare Device 3	Varchar		

Figure 8. Administrative Group Tables (cont.)

<i>Table and Purpose</i>	<i>Field Name</i>	<i>Type</i>	<i>Links to:</i>	<i>Type</i>
<i>Spouses</i> Data about command a member's spouse	Date Updated	Datetime		
	Sailor Social Security Number	Varchar	Sailor.Social Security Number	1→1
	Spouse Date of Birth	Datetime		
	Spouse Gender	Varchar		
	Spouse Name	Varchar		
	Spouse Social Security Number	Varchar		
<i>TAD</i> Temporary Assigned Duty data	Date of Arrival at Destination	Datetime		
	Date of Departure	Datetime		
	Date of Departure from Destination	Datetime		
	Departed from City	Varchar		
	Departed from Command Name	Varchar		
	Departed from Country	Varchar		
	Destination City	Varchar		
	Destination Command	Varchar		
	Destination Country	Varchar		
	Liquidated	Varchar		
	Liquidation Date	Datetime		
	Member Command ID	Varchar	Command Information.Command ID	∞→1
	Member Social Security Number	Varchar	Sailor.Social Security Number	∞→1
	Segment Number	Varchar	TAD Cost.Segment Number	1→1
	TAD ID Code	Varchar	TAD Master.Conference Training ID Code	∞→1
	Tango Number	Varchar		

Figure 8. Administrative Group Tables (cont.)

2. Budget and Supply

The Budget and Supply element of a NSG command is responsible for tracking command expenditures and handling all the supply matters for the individual unit. Its duties encompass balancing all individual budgets, purchasing, providing inventories of command minor properties, liquidating travel claims, ordering equipment and routine supplies, and accounting for all ongoing command expenditures such as electricity and service contracts. The three EIS tables associated with the budget and supply functional group are described below in Figure 9.

<i>Table and Purpose</i>	<i>Field Name</i>	<i>Type</i>	<i>Links to:</i>	<i>Type</i>
<i>Expenses</i> Routine command expenses	Command ID	Varchar	Command Information.Command ID	$\infty \rightarrow 1$
	Purchase Category	Varchar	Purchase Categories.Purchase Category	$\infty \rightarrow 1$
	Purchase Control Number	Varchar		
	Purchase Date	Datetime		
	Purchaser SSN	Varchar	Sailor.Social Security Number	$\infty \rightarrow 1$
	Quantity	Int		
	Stock Number	Varchar	Stock Item Descriptions.Stock Number	$\infty \rightarrow 1$
	Total Price	Money		
	Unit Price	Money		
<i>Properties Listing</i> Command minor property purchases	Command ID	Varchar	Command Information.Command ID	$\infty \rightarrow 1$
	Date Purchased	Datetime		
	Disposal Date	Datetime		
	Inventory	Varchar	Sailor.Social Security Number	$\infty \rightarrow 1$
	Last Inventory Date	Datetime		
	Price	Money		
	Property Description	Varchar		
	Property ID	Varchar	Maintenance.Property ID	$1 \rightarrow \infty$
	Purchase Category	Varchar	Purchase Categories.Purchase Category	$\infty \rightarrow 1$
	Purchaser	Varchar	Sailor.Social Security Number	$\infty \rightarrow 1$
	Subcustodied	Varchar	Sailor.Social Security Number	$\infty \rightarrow 1$
<i>TAD Cost</i> Command travel expenses	Billeting Cost	Money		
	Liquidated	Varchar		
	Liquidation Date	Datetime		
	Miscellaneous Expense	Money		
	Mode of Travel	Varchar		
	Purchase Category	Varchar	Purchase Categories.Purchase Category	$\infty \rightarrow 1$
	Segment Number	Varchar	TAD.Segment Number	$1 \rightarrow 1$
	Tango Number	Varchar		
	Total Cost	Money		
	Travel Cost	Money		
	Type of Billeting	Varchar		

Figure 9. Budget and Supply Group Tables

3. Command

The NSG command element consists of executive personnel who oversee all the functions of a unit. Though not usually responsible for direct data entry, decisions about how the command is to be structured and how workloads are to be shared must be made at this level. The three EIS tables associated with the command functional group are described below in Figure 10.

<i>Table and Purpose</i>	<i>Field Name</i>	<i>Type</i>	<i>Links to:</i>	<i>Type</i>
<i>Command Information</i> Unit level command data	Address	Varchar		
	City	Varchar		
	Command ID	Varchar	Air Crews. Member Parent Command ID	1→∞
			Authorization of Billets.Command ID	1→∞
			Billet Occupation.Command ID	1→∞
			Binnacle List.Command ID	1→∞
			Department.Command ID	1→∞
			Division.Command ID	1→∞
			Expenses.Command ID	1→∞
			Fiscal Authorization.Command ID	1→∞
			Leave.Command ID	1→∞
			Maintenance.Command ID	1→∞
			Properties Listing.Command ID	1→∞
			PRT Data.Command ID	1→∞
			Qualification and Training.Command ID	1→∞
			Sea Crews.Member Parent Command ID	1→∞
			TAD.Member Command ID	1→∞
	Command Name	Varchar		
	Country	Varchar		
	Email	Varchar		
	Notes	Varchar		
	Photograph	Image		
	Postal Code	Varchar		
	Region	Varchar		
	State or Province	Varchar		
	Work Phone	Varchar		
<i>Department Data about departments within a command</i>	Command ID	Varchar	Command Information.Command ID	∞→1
	Department Chief SSN	Varchar	Sailor.Social Security Number	∞→1
	Department Head SSN	Varchar	Sailor.Social Security Number	∞→1
	Department ID	Varchar	Division.Department ID	1→∞
			Maintenance.Department ID	1→∞
	Email	Varchar		
	Telephone	Varchar		
	Title	Varchar		
<i>Division Data about divisions within a department</i>	Command ID	Varchar	Command Information.Command ID	∞→1
	Department ID	Varchar	Department.Department ID	∞→1
	Division Chief SSN	Varchar	Sailor.Social Security Number	∞→1
	Division ID	Varchar	Maintenance.Division ID	1→∞
	Division Officer SSN	Varchar	Sailor.Social Security Number	∞→1
	Email	Varchar		
	Telephone	Varchar		
	Title	Varchar		

Figure 10. Command Group Tables

4. Headquarters

The NSG Headquarters unit supervises all claimancy operations. Their primary responsibility is to set policy and conduct oversight of the community at large. The EIS tables associated with NSG headquarters serve primarily to ensure that uniform sets of data are available to individual commands. Subsequent tables in other functional groups directly reference each table in this group. For example, an operator in the administrative group may assign a Navy Enlisted Classification code (NEC) to a sailor. This value must correspond to an appropriate entry that has been input into the database by a member of the headquarters staff. Referential integrity constraints set by the database schema ensure that incongruous data will not be accepted.

Enabling one central authority to set uniform data parameters is crucial to EIS integrity. As with the command group, NSG headquarters retains some direct data input responsibilities that may not be delegated to the command level. The thirteen tables associated with headquarters functional group are described below in Figure 11.

<i>Table and Purpose</i>	<i>Field Name</i>	<i>Type</i>	<i>Links to:</i>	<i>Type</i>
Authorization of Billets Sets command billets	Billet ID Code	Varchar	Billet Occupation.Billet ID Code	1→∞
	Command ID	Varchar	Command Information.Command ID	∞→1
	Date of Authorization	Datetime		
	Date of Last Update	Datetime		
	Description	Varchar		
	Fill Priority	Int		
	Maximum Paygrade	Varchar		
	Minimum Paygrade	Varchar		
	NEC/Designator 1	Varchar	NEC Description.NEC/Designator	∞→1
	NEC/Designator 2	Varchar	NEC Description.NEC/Designator	∞→1
	NEC/Designator 3	Varchar	NEC Description.NEC/Designator	∞→1
	Other Special Qualifications	Varchar		
	Type Duty	Int	Duty Type Description.Type Duty	∞→1
	UIC	Int		
	Warfare Device Required	Varchar		

Figure 11. Headquarters Group Tables

<i>Table and Purpose</i>	<i>Field Name</i>	<i>Type</i>	<i>Links to:</i>	<i>Type</i>
<i>Billet Occupation</i> Assigns individuals to command billets	Actual Date of Departure	Datetime		
	Billet ID Code	Varchar	Authorization of Billets.Billet ID Code	$\infty \rightarrow 1$
	Command ID	Varchar	Command Information.Command ID	$\infty \rightarrow 1$
	Date Assigned	Datetime		
	Date of Arrival	Datetime		
	Orders Number	Varchar		
	Social Security Number	Varchar	Sailor.Social Security Number	$\infty \rightarrow 1$
<i>Duty Type Description</i> Lists NSG duty types	Tour Length	Float		
	Type Duty	Varchar	Authorization of Billets.Type Duty	$1 \rightarrow \infty$
<i>Fiscal Authorization</i> Sets command budgets	Description	Varchar		
	Allotment	Money		
	Authorization Number	Varchar		
	Command ID	Varchar	Command Information.Command ID	$\infty \rightarrow 1$
	Date of Authorization	Datetime		
	Fiscal Year	Varchar		
	Purchase Category	Varchar	Purchase Categories.Purchase Category	$\infty \rightarrow 1$
<i>Mission Area Description</i> Sets operational areas	Quarter	Varchar		
	Description	Varchar		
	Mission Area ID	Varchar	Flight Mission.Mission Area ID Sea Mission.Mission Area ID	$1 \rightarrow \infty$ $1 \rightarrow \infty$
<i>NEC Description</i> Sets Navy Enlisted Classification Codes job specialties for the community	Description	Varchar		
	NEC Designator	Varchar	Authorization of Billets.NEC/Designator 1	$1 \rightarrow \infty$
			Authorization of Billets.NEC/Designator 1	$1 \rightarrow \infty$
			Authorization of Billets.NEC/Designator 1	$1 \rightarrow \infty$
			Sailor.Primary NEC Designator	$1 \rightarrow \infty$
			Sailor.Secondary NEC	$1 \rightarrow \infty$
			Sailor.Tertiary NEC	$1 \rightarrow \infty$
	Other Special Qualifications	Varchar		
	Source Rating 1	Varchar		
	Source Rating 2	Varchar		
	Source Rating 3	Varchar		
	Source Rating 4	Varchar		
	Source Rating 5	Varchar		
	Technical Advisor	Varchar		

Figure 11. Headquarters Group Tables (cont.)

<i>Table and Purpose</i>	<i>Field Name</i>	<i>Type</i>	<i>Links to:</i>	<i>Type</i>
<i>PMS Description</i> Sets maintenance tasks for the Preventative Maintenance System	Description	Varchar		
	Periodicity	Int		
	PMS Item Number	Varchar	Maintenance.PMS Item Number	1→∞
<i>Position Description</i> Defines operational duty positions	Position	Varchar	Air Crews.Position	1→∞
			Sea Crews.Position	1→∞
	Position Description	Varchar		
<i>Purchase Categories</i> Sets budget line items for command purchases	Description	Varchar		
	Purchase Category	Varchar	Expenses.Purchase Category	1→∞
			Fiscal Authorization.Purchase Category	1→∞
			Properties Listing.Purchase Category	1→∞
			TAD Cost.Purchase Category	1→∞
<i>Stock Item Descriptions</i> Assigns numbers to stock items	Catalog Reference	Varchar		
	Description	Varchar		
	Stock Number	Varchar	Expenses.Stock Number	1→∞
<i>TAD Master</i> List of all Temporary Assigned Duty (TAD) events	Conference Training ID Code	Varchar	TAD.TAD ID Code	1→∞
	Periodicity	Int		
	Reference	Varchar		
	Schedule Date	Datetime		
	Title	Varchar		
<i>Track Dictionary</i> Lists airborne operation tracks	Cognizant Authority	Varchar		
	Track ID	Varchar	Flight Mission.Track ID	1→∞
<i>Training Description</i> Lists training and job qualification requirements	Cognizant Authority	Varchar		
	Reference	Varchar		
	Requal Period	Float		
	Training Description	Varchar		
	Training ID Number	Varchar	Qualification and Training.Training ID Number	1→∞

Figure 11. Headquarters Group Tables (cont.)

5. Maintenance

The NSG command maintenance element is charged with performing both emergency and regularly scheduled preventative maintenance on all the equipment and facilities located at the individual unit. This group is also tasked with providing work

logs for all maintenance conducted. Only one EIS table is associated with the maintenance functional group. It is listed below in Figure 12.

<i>Table and Purpose</i>	<i>Field Name</i>	<i>Type</i>	<i>Links to:</i>	<i>Type</i>
<i>Maintenance</i> Records of all command maintenance preformed	Command ID	Varchar	Command Information.Command ID	$\infty \rightarrow 1$
	Date Conducted	Datetime		
	Department ID	Varchar	Department.Department ID	$\infty \rightarrow 1$
	Division ID	Varchar	Department.Department ID	$\infty \rightarrow 1$
	Emergency Description	Varchar		
	Hours on Job	Float		
	Item ID	Varchar	Properties Listing.Property ID	$\infty \rightarrow 1$
	Maintenance Number	Varchar		
	Person	Varchar	Sailor.Social Security Number	$\infty \rightarrow 1$
	PMS Item Number	Varchar	PMS Description.PMS Item Number	$\infty \rightarrow 1$
	Remaint	Varchar		
	Repair Priority	Varchar		

Figure 12. Maintenance Group Table

6. Operations and Training

The NSG operations and training functional group is responsible for conducting cryptologic operations and ensuring current and complete professional training of all command personnel. The operations group constitutes a major portion of a NSG command and encompasses all air, surface, and submarine operations that may deploy to any point of the globe.

The training group is charged with both initial and follow-on job skills training as well as recording completed training for both the individual and the command as a whole. Although at many individual commands these two responsibilities are delegated to separate departments, they have been combined here for simplicity. The five EIS tables associated with the operations and training functional group are listed below in Figure 13.

<i>Table and Purpose</i>	<i>Field Name</i>	<i>Type</i>	<i>Links to:</i>	<i>Type</i>
<i>Air Crews</i> Records all crewmembers for a flight mission	Flight Mission Number	Varchar	Flight Mission.Flight Mission Number	$\infty \rightarrow 1$
	Flight Serial Number	Varchar		
	Member Parent Command ID	Varchar	Command Information.Command ID	$\infty \rightarrow 1$
	Position	Varchar	Position Description.Position	$\infty \rightarrow 1$
	Social Security Number	Varchar	Sailor.Social Security Number	$\infty \rightarrow 1$
<i>Flight Mission</i> Records data on flight missions	Date Time of Landing	Datetime		
	Date Time of Takeoff	Datetime		
	Duration	Float		
	Exercise Name	Varchar		
	Flight Mission Number	Varchar	Air Crews.Flight Mission Number	$1 \rightarrow \infty$
	Mission Area ID	Varchar	Mission Area Description.Mission Area ID	$\infty \rightarrow 1$
	Platform Number	Varchar		
	Platform Type	Varchar		
	Squadron	Varchar		
	Squadron Crew	Varchar		
	Staged From Base	Varchar		
	Staged From City	Varchar		
	Staged From Country	Varchar		
	Track ID	Varchar	Track Dictionary.Track ID	$\infty \rightarrow 1$
	Type of Mission	Varchar		
<i>Qualification and Training</i> Records individual training completed	Command ID	Varchar	Command Information.Command ID	$\infty \rightarrow 1$
	Completion Date	Datetime		
	Requal	Varchar		
	Sailor Social Security Number	Varchar	Sailor.Sailor Social Security Number	$\infty \rightarrow 1$
	Training ID Number	Varchar	Training Description.Training ID Number	$\infty \rightarrow 1$
<i>Sea Crews</i> Records all crewmembers of a sea-based mission	Member Parent Command ID	Varchar	Command Information.Command ID	$\infty \rightarrow 1$
	Position	Varchar	Position Description.Position	$\infty \rightarrow 1$
	Sea Mission Number	Varchar	Sea Mission.Sea Mission Number	$\infty \rightarrow 1$
	Sea Serial Number	Varchar		
	Social Security Number	Varchar	Sailor.Social Security Number	$\infty \rightarrow 1$
<i>Sea Mission</i> Records data on sea-based missions	Date of Mission	Datetime		
	Exercise Name	Varchar		
	Mission Area ID	Varchar	Mission Area Description.Mission Area ID	$\infty \rightarrow 1$
	Platform Mode	Varchar		
	Platform Name	Varchar		
	Platform Number	Varchar		
	Platform Type	Varchar		
	Sea Mission Number	Varchar	Sea Crews.Sea Mission Number	$1 \rightarrow \infty$
	Type of Mission	Varchar		

Figure 13. Operations and Training Group Tables

VI. SAMPLE SERVER EIS HEIRARCHY

A. INTRODUCTION

1. Sample Site Location

At the onset of this research, the hardware described in section B1 chapter IV was identified for use. After initial hardware checks were concluded, the following steps were taken to establish the sample EIS:

1. The computer's hard drive was reformatted and all NT operating system and database application software was loaded.
2. The system was connected to the Naval Postgraduate School Computer Science "1-net" LAN. This LAN is directly connected to the Internet through in-house hub facilities.
3. The database schema was created in Microsoft Access, and the database was populated with sample data.
4. The Access database was upsized to SQL Server 6.5.
5. The necessary HTM, HTX, and IDC files were created and made available to IIS for publishing to the Internet.

At the time of this writing, the sample NSG EIS can be accessed through URL [<http://cryptologist.cs.nps.navy.mil> or IP address 131.120.1.226].

2. Accessing Sample Site Data

Access to the sample EIS has been divided into seven main web pages that adhere as closely as possible to their corresponding NSG functional areas. An additional general information group with no input responsibility has been added for general access. Each web page contains those operations that would be performed by members of the

particular functional group described in Chapter V. A general roadmap for navigating through the sample site is provided in Figure 14.

A user navigates to the desired page through a series of hyperlink selections. Once at the appropriate web page, the user is free to perform the desired data operation. Each of the specific data operations contained within these functional group main pages is examined in detail in the following sections.

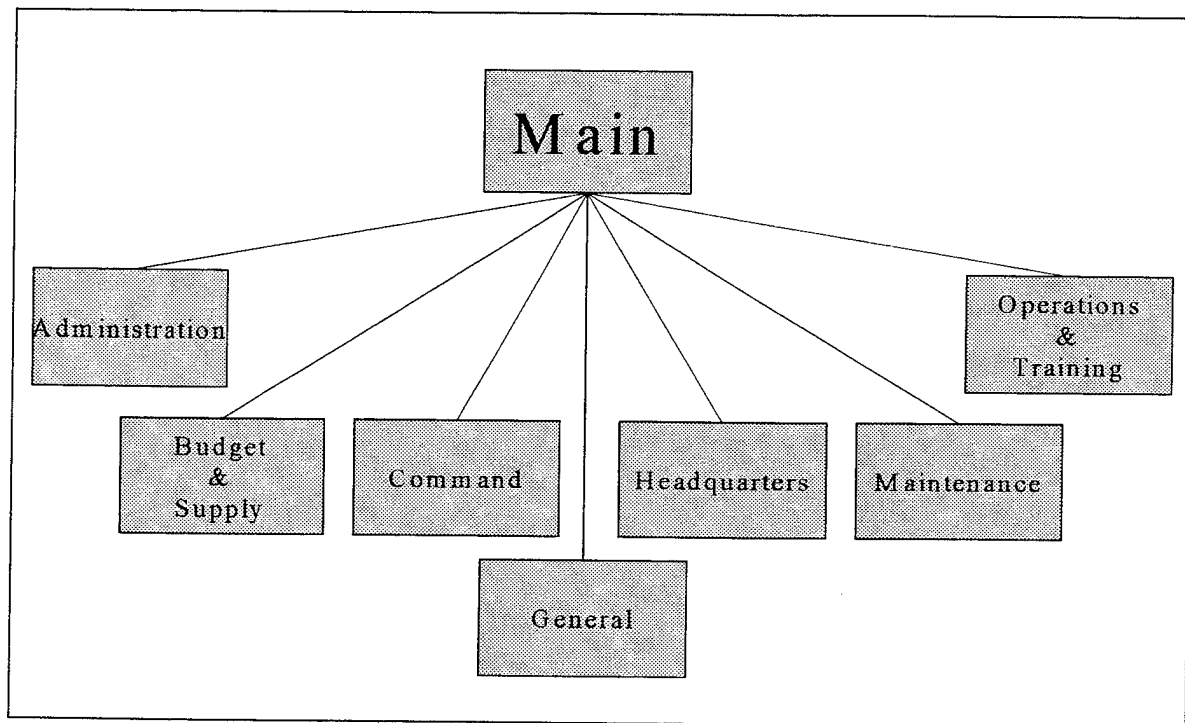


Figure 14. EIS Sample Site Roadmap

B. EIS DATA OPERATIONS

Each functional group main page is separated into a combination of insert, update, and query operations. SQL server 6.5 allows a user to manipulate the database primarily through inserting data, updating data, and performing queries on data. Once the user has gained access to a certain main page, he or she may perform any of the operations that

have been constructed and placed on that page by the database developer. Access to particular web pages is discussed in detail in the next chapter.

Data insertion and update is accomplished through the use of computerized forms that are presented by IIS to the individual user. Each form contains separate data entry blocks necessary for a specific operation. After all appropriate data has been entered into the form, the user submits the form to the database by selecting a "submit" button. The submit routine then commits the data to the database. After submission, the data is permanently inserted or updated to the EIS.

Following submission, the user is returned to a web page from which additional site navigation decisions may be made. If the data entered does not meet preset tolerances, all of the data submitted is rejected. The database roll back to its previous state, an error is logged to the NT operating system, and a message is returned to the user. From this point, the user has the single option of using the web browser to back out of the error message page to the previous form page. Ultimately, the user may either correct the error and resubmit the form or move to a new page.

The most common query requires some input from the user. As with the insert/update operation, when a query's hyperlink is selected, a form is returned to the user. The user completes the form and submits it to the database. However, unlike inserts and updates, a query has no correct or incorrect response from the database. An answer is always returned by the system. If the user has submitted data outside the tolerances of the database, it will simply return a negative answer. All values matching all parameters input by the user will always be returned.

It is possible for the database designer to construct a query that requires no user input. For this type of query, the SQL statement contains all the data parameters necessary to return results. In this case, the user simply clicks the hyperlink with the name of the query. The hyperlink calls the corresponding SQL statement that performs a select operation on the database and the results are returned to the user.

Most often, multiple inserts, updates, and queries are combined within one operation. The nature of these operations is purposefully transparent to the user. The average user should not care how the EIS performs its job, only that it does accurately and efficiently. In addition, SQL provides operations that change the form of the data without changing the data content itself. This implementation of the EIS makes full use of these utility functions. Data is routinely converted from one input form for storage in the database and converted back for display to the user without the user's knowledge. Such data conversions are necessary in order to maximize utility within the EIS. Samples of some of the various insert, update, and query operations contained in EIS IDC files are provided in Appendix B. In addition, examples of the computerized forms and data return pages in the form of HTM and HTX files have also been made available.

The remainder of this section outlines the operations available within each of the main web pages. Figures 15-21 give a complete listing of these operations sorted alphabetically by functional group name.

1. Administration

Hyperlink name	Function	SQL operation	Affected Tables
Binnacle List Entry	Adds a sick list entry to a specified command	Insert	Binnacle List
Family Members	Lists all family members of a specified command member	Select	Family Members Sailor
Initial Travel Claim	Adds initial command travel claim data	Insert	TAD TAD Cost
Leave Entry	Adds an individual leave entry	Insert	Leave
Leave Report	Lists all leave information on a specified command member	Select	Leave Sailor
Losses List	Lists all command members scheduled to rotate from a specified command within six months of today's date	Select	Billet Occupation Command Information Sailor
Mailing List	Lists the addresses of all members of a specified command	Select	Billet Occupation Command Information Sailor
New Family Member	Adds a family member to the household of a specified command member	Insert	Family Members
New NEC	Adds a new NEC to a selected sailor	Select Update	Sailor
New Spouse	Adds a spouse to a specified command member	Insert	Spouses
New Warfare Device	Adds a new warfare device to a specified command member	Select Update	Sailor
Personal Days Deployed	Calculates the number of days a specified command member is deployed from a selected command over a given timeframe	Select	Billet Occupation Command Information Sailor TAD TAD Master
Personal PRT Results	Lists all PRT entries for a specified command member	Select	PRT Data Sailor
Personal Sick Days	Lists all workdays missed due to illness for a specified command member	Select	Binnacle List Sailor
Promote Sailor	Changes a specified command member's rank	Select Update	Sailor
PRT Entry	Adds an individual PRT entry	Insert	PRT Data
Sailor Address	Changes the address of a specified command member	Select Update	Sailor
Sailor Marital Status	Removes the spouse of a specified command member	Select Update	Sailor Spouses
Spouses	Lists the spouse of a specified command member	Select	Sailor Spouses
Travel Claims	Lists all details of an individual travel claim	Select	TAD TAD Cost TAD Master

Figure 15. Administration Main Page Operations

2. Budget and Supply

Hyperlink name	Function	SQL operation	Affected tables and fields
All Budget Totals By Date	Calculates the total expenditures of a specified command by selected budget line item for a given timeframe	Select	Expenses Properties Listing Purchase Categories TAD TAD Cost
Assign Minor Property Custody	Assigns minor property custody to a specified command member	Select Update	Properties Listing
Dispose of Minor Property	Removes minor property from a specified command's inventory	Select Update	Properties Listing
General Expenses and Purchases	Adds a record of purchase for general items to a specified command	Insert	Expenses
General Expenditures By Date	Lists all general expenditures of a specified command for a given timeframe	Select	Billet Occupation Command Information Expenses Sailor Stock Item Descriptions
General Expenditures By Item	Lists all information about a command general purchase by item number	Select	Billet Occupation Command Information Expenses Sailor Stock Item Descriptions
Liquidate Travel Claim	Assigns liquidated values to specified command travel claims	Update	TAD TAD Cost
Minor Property Custody Listing	Adds a record of purchase for minor property to a specified command	Insert	Properties Listing
Minor Property Expenditures By Date	Lists all minor property purchases for a specified command for a given timeframe	Select	Command Information Properties Listing Sailor
Minor Property Expenditures By Item	Lists all minor property purchase data by item number for a specified command over a given timeframe	Select	Command Information Properties Listing Sailor
Minor Property Purchases	Adds a record of purchase of minor property to a specified command	Insert	Properties Listing

Figure 16. Budget and Supply Main Page Operations

3. Command

Hyperlink name	Function	SQL operation	Affected tables and fields
Add New Department	Adds a new department to a specified command	Insert	Department
Add New Division	Adds a new division to a specified command	Insert	Division
Annual Balance Report	Calculates the account balances of specified budget line items for a selected command over a given timeframe	Select	Expenses Fiscal Authorization Properties Listing Purchase Categories TAD TAD Cost
Billets Filled	Lists all manned billets at a specified command	Select	Authorization of Billets Billet Occupation Command Information Sailor
Billet Structure	Lists all billets assigned to a command	Select	Authorization of Billets Command Information
Binnacle List Statistics	Calculates total days lost due to illness or injury at a specified command	Select	Binnacle List Command Information
Change Department Information	Changes department data at a specified command	Insert Update Select	Department Sailor
Change Division Information	Changes division data at a specified command	Insert Update Select	Division Sailor
Command Demographics By Gender	Sums all active members of a specified command by gender	Select	Billet Occupation Command Information Sailor
Command Demographics By NEC	Sums all active members of a specified command by NEC	Select	Billet Occupation Command Information Sailor
Command Demographics By Rank	Sums all active members of a specified command by rank	Select	Billet Occupation Command Information Sailor
Command Demographics By Rate	Sums all active members of a specified command by rating	Select	Billet Occupation Command Information Sailor
Command Structure	Lists the structure of a specified command and the personnel locally assigned to key positions	Select	Command Information Department Division Sailor
Days at Sea	Calculates the number of days members of a specified command have spent deployed to sea	Select	Command Information TAD TAD Master
Emergency Recall List	Lists points of contact for key personnel at a specified command	Select	Command Information Department Sailor

Figure 17. Command Main Page Operations

Flight Hours By Mission	Sums all flight hours for members of a specified command and lists these by individual flight mission over a given timeframe	Select	Air Crews Command Information Flight Mission
Flight Hours Total	Calculates the total number of flight hours flown by a specified command for a given timeframe	Select	Air Crews Command Information Flight Mission
PRT Report	Lists all members and their PRT scores of a specified command by PRT level for a given timeframe	Select	PRT Data Sailor
Quarterly Balance Report	Calculates the account balances of specified budget line items for a selected command over a quarterly timeframe	Select	Expenses Fiscal Authorization Properties Listing Purchase Categories TAD TAD Cost
Reenlist Sailor	Changes reenlistment and EAOS data for a specified command member	Select Update	EAOS Data
Retention Statistics	Compares the totals of command members who reenlisted to those eligible for reenlistment for a specified command over a given timeframe	Select	Billet Occupation Command Information EAOS Data Sailor
Roster	Lists name, rank and social security number for all members of a specified command	Select	Billet Occupation Command Information Sailor
Sailor Check-in at Command	Adds a sailor to a specified command	Update	Billet Occupation
TAD Report	Lists all members of a specified command and the total days deployed by trip for a selected TAD category who have departed within a given timeframe	Select	Billet Occupation Command Information Sailor TAD TAD Master
Transfer Sailor	Releases a specified command member from a selected command	Select Update	Billet Occupation Department Division Properties Listing
Upcoming Reenlistments	Lists all members of a specified command who are eligible for reenlistment within 90 days of today's date	Select	Billet Occupation Command Information EAOS Data Sailor

Figure 17. Command Main Page Operations (cont.)

4. General

Hyperlink name	Function	SQL operation	Affected tables and fields
Command Directory	Lists official contact points for key departments and divisions of a specified command	Select	Command Information Department Division
Cryptologic Officer Listing	Lists the names and dates of rank of all officers within the NSG claimancy	Select	Sailor
Detailer Report	Lists all available NSG positions corresponding to specified billet criteria for a given timeframe	Select	Authorization of Billets Billet Occupation Command Information Duty Type Description
NSG Command Listing	Lists the names and address of all active NSG commands	Select	Command Information
Personnel Locator	Lists a current official point of contact for a specified individual	Select	Billet Occupation Command Information Sailor

Figure 18. General Main Page Operations

5. Headquarters

Hyperlink name	Function	SQL operation	Affected tables and fields
Add Command	Adds a new command to the NSG claimancy	Insert Select	Command Information
Add Conference	Adds a new conference	Insert Select	TAD Master
Add PMS Task	Adds a new PMS line item	Insert Select	PMS Description
Add Sailor	Adds a new sailor to the NSG	Insert Select	Sailor
Add Supply Stock Number	Adds a new stock item	Insert Select	Stock Item Descriptions
Add Training Event	Adds a new training line item or qualification	Insert Select	Training Descriptions
Authorize Billet	Adds a new billet to a specified command	Insert Select	Authorization of Billets
Binnacle List Statistics	Calculates the number of days lost at all NSG commands	Select	Binnacle List Command Information
Command Budgets	Lists the budget allowances of each NSG command for a given fiscal timeframe	Select	Command Information Fiscal Authorization Purchase Categories
Commanding Officer Listing	Lists the commanding officers of all NSG commands	Select	Billet Occupation Command Information Department Sailor

Figure 19. Headquarters Main Page Operations

Days at Sea	Calculates the total days deployed to sea throughout all NSG commands for a given timeframe	Select	TAD TAD Master
Discharge Sailor	Removes a sailor from the NSG claimancy	Insert Select	Department Division EAOS Data Properties Listing
Demographics By Gender	Sums all active members of all NSG commands by gender	Select	Billet Occupation Sailor
Demographics By NEC	Sums all active members of all NSG commands by NEC	Select	Billet Occupation Sailor
Demographics By Rank	Sums all active members of all NSG commands by rank	Select	Billet Occupation Sailor
Demographics By Rate	Sums all active members of all NSG commands by rating	Select	Billet Occupation Sailor
Flight Hours	Calculates the total number of flight hours flown throughout the NSG by command for a given timeframe	Select	Air Crews Command Information Flight Mission
Order Sailor To Command	Assigns a NSG sailor to a specified billet at a selected command	Insert	Billet Occupation
Personnel Listing	Lists name, rank and social security number for all members by command	Select	Billet Occupation Command Information Sailor
Retention Statistics	Compares the totals of NSG members who reenlisted to those eligible for reenlistment for a given timeframe	Select	Billet Occupation EAOS Data Sailor
Retirements	Lists all former NSG personnel who have retired during a given timeframe	Select	EAOS Data Sailor
Retire Sailor	Retires an NSG sailor from the NSG claimancy	Insert Select	Department Division EAOS Data Properties Listing
Sailor Duty History	Lists all career billets and command assignments for a specified NSG member	Select	Authorization of Billets Billet Occupation Command Information Sailor
Set Command Budget	Assigns a monetary amount to a specified budget line item for a specified command	Insert Select	Fiscal Authorization
Unliquidated Travel Claims	Lists all travel claims throughout NSG commands that are not liquidated	Select	TAD TAD Cost TAD Master

Figure 19. Headquarters Main Page Operations (cont.)

6. Maintenance

Hyperlink name	Function	SQL operation	Affected tables and fields
Command/Department Maintenance Records	Lists all maintenance conducted for a specified department at a selected command for a given timeframe	Select	Command Information Maintenance PMS Description
Full Maintenance List	Lists chronologically all maintenance ever conducted at a specified command	Select	Command Information Maintenance PMS Description
Item Maintenance History	Lists all maintenance conducted on a specified item	Select	Maintenance PMS Description Properties Listing
Maintenance Log	Adds a completed maintenance record	Insert Update	Maintenance
Personal Maintenance Log	Lists all maintenance conducted by a command member during a given timeframe	Select	Maintenance PMS Description Sailor
Upcoming Maintenance Tasks	Lists all maintenance required for a specified department and command within	Select	Command Information Maintenance PMS Description

Figure 20. Maintenance Main Page Operations

7. Operations and Training

Hyperlink name	Function	SQL operation	Affected tables and fields
Add Air Mission	Adds a completed flight mission	Insert Select	Flight Mission
Add Sea Mission	Adds a completed sea mission	Insert Select	Sea Mission
*Air Missions Query	Lists all air missions flown specified by mission area, mission type, platform, and squadron during a given timeframe	Select	Flight Mission Mission Area Description
*Air Missions Aircraft BuNo Sort	Lists all air missions flown by aircraft bureau number during a given timeframe	Select	Flight Mission Mission Area Description
*Air Missions - Sort By Exercise	Lists all air missions flown by exercise name during a given timeframe	Select	Flight Mission Mission Area Description
*Air Missions - Sort By Mission Area	Lists all air missions flown by mission area during a given timeframe	Select	Flight Mission Mission Area Description
*Air Missions - Sort By Mission Type	Lists all air missions flown by mission type during a given timeframe	Select	Flight Mission Mission Area Description
*Air Missions - Sort By Platform Type	Lists all air missions flown by aircraft type during a given timeframe	Select	Flight Mission Mission Area Description

Figure 21. Operations and Training Main Page Operations

*Air Missions - Sort By Squadron and Crew	Lists all air missions flown by squadron and crew during a given timeframe	Select	Flight Mission Mission Area Description
*Air Missions - Sort By Staging Area	Lists all air missions flown by aircraft bureau number during a given timeframe	Select	Flight Mission Mission Area Description
*Air Missions - Sort By Time	Lists all air missions chronologically during a given timeframe	Select	Flight Mission Mission Area Description
*Air Mission - Sort By Track	Lists all air missions flown by air track during a given timeframe	Select	Flight Mission Mission Area Description
*All Missions Query	Lists all operational missions specified by exercise name, mission area, and mission type during a given timeframe	Select	Flight Mission Mission Area Description Sea Mission
Completed Training	Adds a completed training event or qualification	Insert Update	Qualification and Training
Personal Days at Sea By Platform	Calculates the number of days at sea for a specified individual by platform for a given timeframe	Select	TAD TAD Master Sailor
Personal Days at Sea Career	Calculates the total number of days at sea for a specified command member	Select	TAD TAD Master Sailor
Personal Flight Hours By Mission	Lists all flights flown by a specified command member during a given timeframe	Select	Air Crews Flight Mission Sailor
Personal Flight Hours Career	Calculates the total flight hours for a specified individual	Select	Air Crews Flight Mission Sailor
Personal Training History	Lists all training completed for a specified individual	Select	Qualification and Training Sailor Training Descriptions
Qualification/Training Delinquent List	Lists all training and qualifications at a specified command that will expire within 90 days	Select	Qualification and Training Sailor Training Descriptions
*Sea Missions Query	Lists all sea based missions specified by mission area, mission type, and platform type during a given timeframe	Select	Mission Area Description Sea Mission
*Sea Missions - Sort By Exercise	Lists all sea based missions by exercise name during a given timeframe	Select	Mission Area Description Sea Mission
*Sea Missions - Sort By Mission Area	Lists all sea based missions by mission area during a given timeframe	Select	Mission Area Description Sea Mission
*Sea Missions - Sort By Mission Type	Lists all sea based missions by mission type during a given timeframe	Select	Mission Area Description Sea Mission
*Sea Missions - Sort By Platform Mode	Lists all sea based missions by platform mode during a given timeframe	Select	Mission Area Description Sea Mission

Figure 21. Operations and Training Main Page Operations (cont.)

*Sea Missions - Sort By Platform Name	Lists all sea based missions by platform name during a given timeframe	Select	Mission Area Description Sea Mission
*Sea Missions - Sort By Platform Side Number	Lists all sea based missions by platform number during a given timeframe	Select	Mission Area Description Sea Mission
*Sea Missions - Sort By Platform Type	Lists all sea based missions by platform type during a given timeframe	Select	Mission Area Description Sea Mission
*Sea Missions - Sort By Time	Lists all sea based missions chronologically during a given timeframe	Select	Mission Area Description Sea Mission
* Indicates that this query is reached through the additional Operations and Training page hyperlink "All Missions"			

Figure 21. Operations and Training Main Page Operations (cont.)

C. SAMPLE DATA

Actual data from NSG operations was not used to populate the sample EIS. However in order to illustrate system functionality, data has been entered into the system that closely resembles possible events that occur daily within the NSG. Each of the aforementioned EIS functional groups tables contains some data points with which the user can experiment.

Two shore based command level units and one staff element have been created to serve as representative samples. Each command has been subdivided into appropriate departments and divisions and populated with fictitious officer and enlisted personnel from all NSG technical subspecialties. Data on personnel, TAD trips, budget expenditures, and other typical NSG operations have also been included. Combined, this data simulates NSG operations for approximately 100 personnel.

Due to the amount of time necessary to manually enter several years of actual data, only representative samples of each functional group have been entered. Approximately five megabytes of data currently reside in the sample EIS server.

VII. SECURITY

A. BASIC DATABASE SECURITY

For a database system to be reliable, the data it contains must be accurate and complete. In order to achieve a high degree of reliability, the database designer must consider the security of the system. The principal concerns of database security are data integrity, data privacy, and data availability [Ref. 14].

1. Data Integrity

A database query will only return correct results if it has trustworthy data upon which to base a conclusion. To guarantee data integrity is to certify that all the data in the database is factual and of the correct type.

Data integrity also implies that data updates cannot be repudiated once committed. Data transactions must be verifiable, committed only by authorized personnel, and impossible to change or undo. Protecting the integrity of data is crucial to the proper operation of an EIS.

2. Data Privacy

Certain combinations of database data should not be accessible by everyone. Some information needs to be seen only by supervisory personnel while other data is simply private. Good examples within the NSG EIS are personal data, such as family information or social security numbers, and claimancy fiscal data. Ref. 15 gives a listing of privacy related information that should be protected.

Releasing data on a strict need-to-know basis is a staple of military operations. In order to ensure data privacy, some means of authenticating an authorized user to the appropriate data object must be assured.

3. Data Availability

If the EIS is to be useful to the community as a whole, the availability of the data through the server must be maintained. Because it is designed to be accessible through the Internet, an EIS is more vulnerable to data availability attacks than a stand-alone database system. If access to the database server can be blocked, access to the data it contains is denied. An EIS that is unavailable to the enterprise is of little use.

B. SYSTEM SPECIFICATIONS

1. Overview

The NSG EIS is designed to be accessible by anyone only through the Internet. Although there are numerous computer system attacks that encompass a wide variety of computing techniques, safeguarding against all network attacks is beyond the scope of this thesis. This chapter deals with security concerns encountered through the legitimate use of the system.

The web server (HTTP protocol) is not the only service that allows a user to network to a computer. File Transfer Protocol (FTP), Gopher, telnet and many other network applications have been designed to allow computers to communicate with one another. At the sample site, most of these services have been intentionally disconnected in order to restrict unauthorized access to the server and to maximize system resources.

In addition, the security weaknesses of the Microsoft NT operating system are not specifically addressed here. The National Security Agency has documented a comprehensive listing of Microsoft NT security problems and potential solutions in Ref. 16.

Personnel can access the database through the Naval Postgraduate School "1-net" or through the keyboard interface at the server terminal. Legitimate Internet access is gained only through the client's use of a web browser to connect to the site's IIS web server. The specific order of events that must occur in order for data to be retrieved from the database is listed below. Each of these events involves communications between the server's NT operating system, the web server and the database server.

1. A client contacts the site's web server by entering the site's URL.
2. Upon contact, the site's web server confers with the server operating system for the resources to grant the user's connection request.
3. The web server locates its default page, the first page to be presented to the user.
4. Each web directory possesses a unique list of authorized viewers. If anonymous web access is permitted, the web server presents the default page to the user. Otherwise, the user is presented with a login script that the web server must validate with the operating system.
5. If a selected operation also involves a connection to the database, the web server communicates to the operating system that the database server is needed.
6. The operating system communicates this request to the database server along with the identification of the user.
7. Like the web server, the database server contains a separate control list that it uses to determine access to the data. It compares the user's

8. If the user is recognized, the data is fetched from the database and sent back to the operating system for further transport to the web server and presentation to the user. If the user is not permitted access to the data, an appropriate message is passed in lieu of the data.

```

graph TD
    User[USER] --> WebServer[Web Server]
    WebServer -- Data --> OS((Operating System))
    OS -- Data --> WebServer
    OS --> WebPage1[Web Page]
    WebPage1 --> Auth1[Authenticate User]
    Auth1 --> NoAuth1[No Authentication]
    NoAuth1 --> Denied1[Web Page Access Denied]
    Auth1 --> AccessAllowed1[Access Allowed]
    AccessAllowed1 --> WebPage2[Web Page]
    WebPage1 -- "Request Access to New Web Page" --> Login(Login)
    Login --> Auth2[Authenticate User]
    Auth2 --> OS
    WebPage1 -- "Access to General Data Only" --> Auth3[Authenticate User]
    Auth3 --> DBServer[Database Server]
    DBServer -- Data --> DB[(Database)]
    DB -- "Access to General Data Only" --> DBServer
    DBServer -- "Specific Access" --> DB
    DBServer -- "No Authentication or Insufficient Permission" --> Denied2[Database Access Denied]
    
```

Legend: — Anonymous Login

As described above, both IIS 3.0 and SQL Server 6.5 have their own separate security features. Each of these depends to some degree on the capabilities of the Microsoft NT operating system.

The operating system software constructs a default access control list (ACL) when initially installed that describes who may access the server. The ACL is based on a set of security policies that can be altered by the SA. Thus, the SA decides who may gain entry to the system by changing the ACL and how access may be gained by changing the system security policies.

Similarly, the SA constructs an ACL for each web page and for each SQL server database. The operating system, the web server and the database server are all configured independently but reference the NT ACL to define user access to individual web pages and the database. The separate configurations of the operating system, the web server, and the database server are examined in detail in the following sections.

By tailoring individual security policies and ACLs, the web server and database server can select which users may view certain web pages and which users may affect data. The responsibility of the web server and database server with respect to data integrity, data privacy, and data availability are listed below in Figure 23.

	IIS	SQL Server
Data Integrity	Ensures that only appropriate individuals may access web pages. As web pages contain data insert and update routines, only authorized personnel may alter data.	Allows only certain data operations for selected database tables.
	Allows only preformatted forms to be presented to users.	
Data Privacy	Allows only appropriate individuals access to web pages containing query routines that return sensitive data.	Allows only authorized individuals to conduct queries of certain tables.
Data Availability	Refuses web connections by other than authorized users.	Refuses database connections by other than authorized users.

Figure 23. NSG EIS Server Security Features

2. Operating System Security Configuration

The Microsoft NT operating system has increased in popularity primarily due to its ease of use. Its availability and wide use have also made it the target of choice by hackers [Ref 16: p. 1]. A listing of its vulnerabilities is readily available on the Internet. Though not designed for use in a highly secure environment, Microsoft has taken significant steps to contain these vulnerabilities and upgrade NT security features. The NSA ref contains a listing of necessary configuration changes in order to upgrade the security classification of the system to its highest possible (C2) level of trust.

The Microsoft NT operating system collects most administrative functions into a set of functions known as Administrative Tools. Using these tools, domains are created to partition work among computers and users and maximize system resources. A domain is technically defined as "a collection of computers and users that share a common directory services database [Ref. 16: p. 8]." Multiple domains may exist on the same server.

In addition, the SA is allowed to create groups of users. Groups are defined in order to allow numerous people with similar working responsibilities to have the same permissions. Groups allow the SA to classify users according to how they use the computer system.

Once a domain and group have been established, the SA may add a user and their password to the ACL. When a user logs onto the NT server, the operating system cross-references the login name to a security identifier that was created when the SA created the user's account. This security identifier is unique to the system and is never displayed.

Within the NT environment, all system resources are treated as separate objects. The ACL matches the user's security identifier to the specified objects that the SA deems appropriate. The ACL delineates all the rights that a user possesses within the system.

The security configuration of the operating system needs little change for legitimate usage. Only one domain has been created and all default groups have been maintained. New users have been added only to the Administrator group, the Users group, or the Guests group. The guest account has been retained for anonymous login purposes only. This group would be removed and an NSG-wide group and password created upon actual implementation. All other groups have been removed from the NT operating system.

3. Web Server Security Configuration

The IIS 3.0 security options allow the system to differentiate between all users based on a user-input name and password. Recognized users are allowed to view specified web pages based on a comparison against the pre-established individual permissions.

A web page must be contained in a directory. Directories are grouped separately by the web author in the web server. One directory must be fixed as the root directory. Using the default settings, the root directory is the first directory accessed by IIS. In addition, one page within each subdirectory must be labeled as the default page for that directory.

When the root directory is created in Front Page 98, the web author may specify one of two conditions that will determine what accesses to a web page will be allowed:

1. Only users previously registered with the operating system have browse access.
2. Everyone has browse access.

If the first option is selected, the web author must specify which users will have access. This may be done individually or by designating an entire group. The directory creator is presented with a list of authorized NT users and groups for the domain on which the web server resides. The web author may only select from the list of authorized users, groups, and domains created by the SA.

A web designer usually wants to make a site maximally available. A prohibitive amount of computer resources would be needed if the Operating System and Web Server were required to maintain the names and passwords for all web users on the Internet. To preserve computer resources, the DBA uses group permissions as much as possible.

To allow maximum access, the web author selects the second option to admit anyone into the default page. Viewing subsequent pages is based on authenticated membership to previously assigned groups. In effect, anyone can visit the site but only approved individuals may view the web pages the DBA has determined they need to know.

IIS creates an anonymous user account with a random password when the server is installed. The anonymous user is logged in as the user when no special access is designated for a web directory. The system web author may delete or reconfigure this account through the IIS Internet Service Manager. If this account is deleted, a user must have an account on the server in order to make an initial connection to the web server.

For non-root directories, the web author may specify that a directory has the same permissions as the root page or that it has unique permissions. The first option allows the web author to use the same ACL to control multiple directories. Unique permissions for subsequent directories are controlled in the same manner as those of the root directory.

The operating system caches the user's last login. If subsequent web pages are located in the same directory or the newly selected directory has the same permissions as the previous directory, no new login is required. An authentication script is invoked only if the current login does not match the permission listed for the newly selected directory. This cached login is used for database server access as well. Database access is discussed in the next section.

For the NSG EIS, the web pages have been sorted into the directories previously described in Chapter VI. The anonymous user is allowed access only to the root directory, the general directory and the guest book. Other directories contain user groups and passwords unique to that NSG functional group. The only legitimate way to access unique group data is through a specialized web page. Only group personnel who are listed in the ACL for that page's directory and know the proper password may perform these operations.

Thus, when an NSG user uses a web browser to access the sample site, the root directory default page is presented through anonymous login. From here, the user may select a hyperlink to another page.

If this page is other than the general directory or the guest book, IIS presents an authentication script to the user who must input a unique name and password. IIS will pass this data to the operating system and check it against the NT ACL. If the user name

and password match the ACL, and the user is authorized for that web directory, the user is allowed to view any page within that directory.

The user can perform up to three consecutive authentication tries. If the user name and password do not match, the web server will not retrieve the desired page. Instead it displays a message saying that access is denied. The user must then use the browser to return to the previous authorized page. It is possible for the web author to modify the number of authentication attempts using the IIS Internet Service Manager.

Web server authentication operations are depicted in Figure 24.

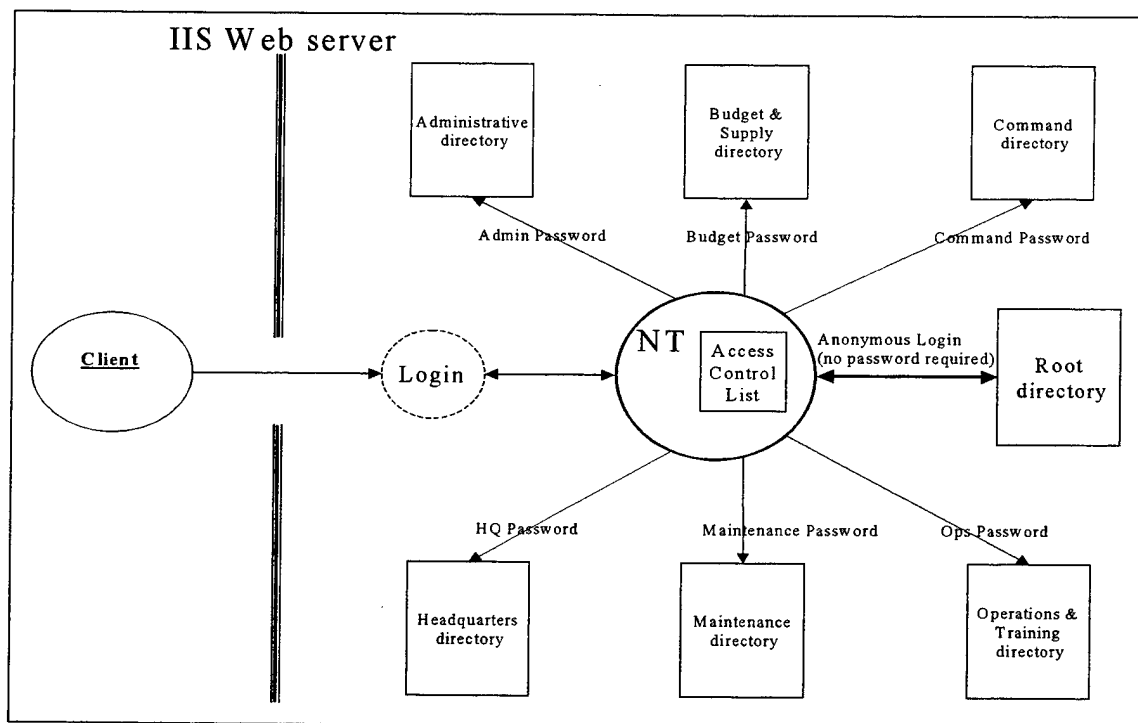


Figure 24. IIS Security

The IIS web security features concentrate mainly on data privacy. However, the web-based interface allows the web author to implement some data integrity features as well. For example, if an authorized user attempts to insert the wrong data type into a field, the database server rejects it and returns an error message. Using preformatted

insert and update web pages, it is possible to decrease reliance on the database server to solely filter out mismatched data types.

Front Page 98 allows the database designer to construct forms that contain syntactically correct inputs. Form tools such as drop-down boxes and radio buttons require the user to select from valid entries instead of freely entering data. Ensuring that only certain fields are available to the user helps preserve data integrity and reduces frustration on the part of the user.

Using the IIS Internet Service Manager, the SA may specify the maximum number of connections, the maximum data rate, and the maximum connection time a client may remain connected to the server. In addition, certain computers may be denied web access based on their IP address. Each of these tools allows the SA to further configure web server security and maximize data availability.

To minimize remote access of the operating system, actual implementation of the NSG EIS require isolating the web server as much as possible from other system files. This would be best accomplished by mounting the web server on a separate computer configured solely for web service. In this manner, web server performance could be optimized, and a security breach to the web server would not affect system files contained on the main computer.

4. Database Server Security Configuration

Like the web server, the database server may be configured to enhance the security of the system using a set of security policies and an ACL. In contrast, the database server directly fetches data from the database. Through this direct interaction,

the database server is much more capable of ensuring data integrity and proper access to the database tables.

Configuring security in SQL 6.5 requires using two separate tools. The first, the SQL 6.5 Security Manager is very similar to the NT Administrative Tools. It allows the DBA to define groups, users, and connection times for each individual database.

The second tool, the SQL Server 6.5 Enterprise Manager, allows the DBA to assign object permissions to each of these groups and user, where objects are defined as tables and fields. Thus, users can be granted delete, insert, select, and update authority by field and table in an ACL similar to, but separate from, the NT ACL. The Enterprise Manager affords a high degree of granularity when granting database access.

When SQL Server 6.5 is installed, it loads a set of security rules known as the default mode. When operating in the default mode, any passwords that have been input to the operating system are ignored. Only the user name and password that have been permanently coded in the IDC file are used for database access.

For a web-based application such as the EIS, this default must be changed through the Enterprise Manager. In order to implement a challenge-response system, SQL Server must be reset to the integrated security mode. When operating in the integrated security mode, the database server uses the password input for the web server to access the database as well.

In practice, a user requests access to data by selecting a data operation from a web page. The web server passes this request to the operating system, which in turn contacts the database server. The password that has been cached by the operating system is passed to the database server along with the SQL statement.

When database access is requested, the database server checks this password against its ACL to determine whether this user has sufficient permission to execute the SQL statement. Like IIS 3.0, either the data or an error message is returned to the user. SQL Server 6.5 database authentication operations are depicted in Figure 25.

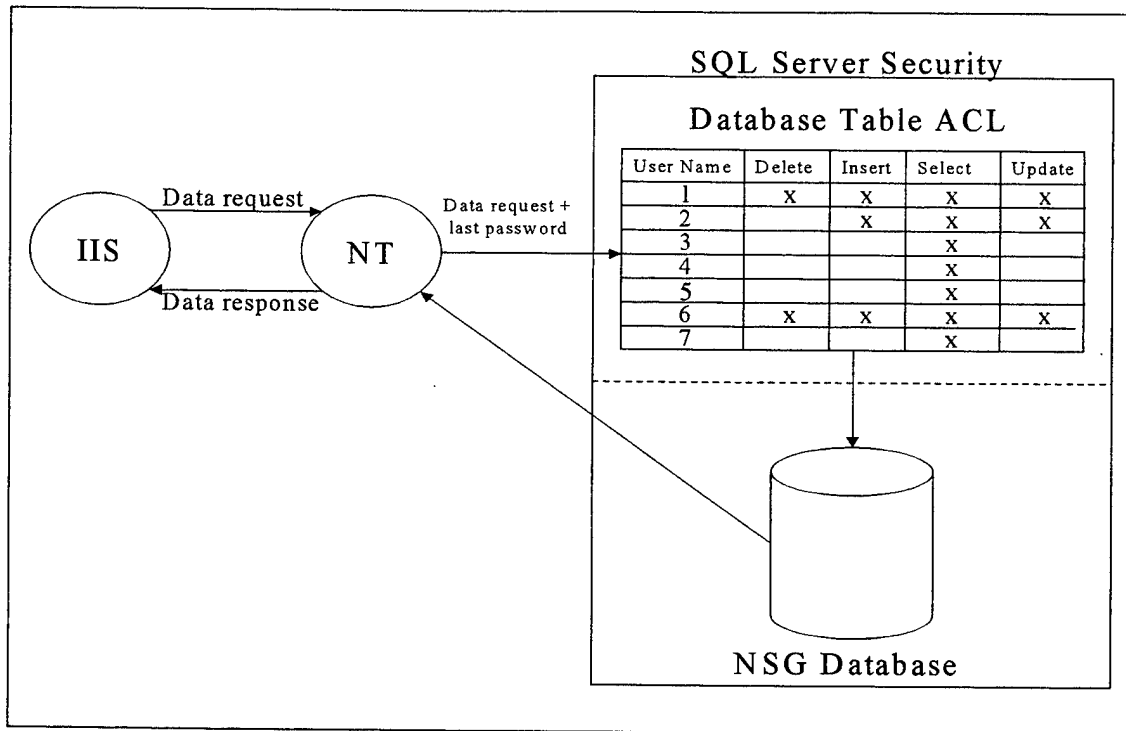


Figure 25. SQL Server Security

SQL Server 6.5 security procedures ensure that only approved personnel can view or modify tables. Combining these features with those previously mentioned for IIS ensure that data integrity and data privacy are ensured for the system.

The Enterprise Manager also allows optimization of the database. The DBA may specify how many connections are allowed at a time, how many objects and databases may be open simultaneously, how long a connection may remain idle before it is

terminated, and how long a user may remain logged onto the database. Using these configuration options, the DBA can help to ensure data availability.

Again, were the NSG EIS to be actually implemented, it would be best to separate the database server from the main file system. This would allow the system to be optimized for performance and minimize system damage should security be breached.

C. OTHER SECURITY FEATURES

1. Database Organization

Proper relationships between database tables and fields combined with good programming practices help protect against repudiation of data. All NSG EIS SQL insert and update statements contain an if-then conditional programming clause to ensure that only syntactically correct, non-duplicate data is entered into the database.

When a user submits data, SQL Server 6.5 uses the IDC file to determine where to put the data. The IDC file if clause checks the table to see that the table and key value exists and that the data to be entered is of the correct type. In certain instances, other fields may be checked to ensure that a previous update operation cannot be undone. This extra data integrity check is dependent of the particular NSG EIS operation. If the data is proper, then the data is added to the database. There is no change to the database and an error message is returned to the user otherwise.

In addition, SQL Server 6.5 observes the time when an insert or update operation is conducted based on its own internal clock. The software can be made to place this timestamp and the logon id of the user as a field in the appropriate table when a transaction is conducted. Separate constraints can be placed on fields to specify valid update times or limit intervals between modifications. Although these techniques were

not specifically used in the NSG EIS, their implementation would help assure non-repudiation of data transactions and strengthen data integrity.

2. Logs

System logs are an important security tool common to most systems. Logs do not prevent inappropriate system usage but rather documents system users and any problems that may have been encountered. Logs are usually considered legal documents and should be written to removable or read-only media to prevent tampering. NT provides both an application log and a security log that allow the SA to view who has accessed various portions of the NSG EIS.

The NT application log shows a comprehensive list of users that have invoked the database server. This function allows the SA to view the date, time, source, category, event, and user name each time a query or data operation has been run.

The NT security log simply shows what users have logged on to the server. Like the application log, it lists the date, time, source, category, event, user name, and computer from which the server has been accessed.

In addition, IIS makes an entry into a separate log each time a web page is accessed. This log records the date, the web page accessed, the operation performed and the IP address of the machine that contacted the NSG server. A new log file is started each day. The files from previous days are logged in the WINNT\System32 directory. The log file name and storage site are configurable by the SA.

It is possible to log all server users directly to a SQL database table using the Internet Service Manager. Though not initiated for the sample site, this option allows the DBA to automate routines to check who is accessing the database as well as how and

when it is being utilized and what pages are being utilized the most. Such data provides a valuable tool for optimizing database resources.

3. Database Redundancy and Backups

One last fundamental requirement of large systems is backup. Backups provide recovery from system failure due to system failure, security breach, and natural disaster. Databases should be backed up to separate, removable media faithfully and frequently.

SQL Server 6.5 has made the task of backing up data files simple for the DBA. Using the Enterprise Manager, the database schema and all data can be copied quickly and easily to the local disk or a remote server. The DBA need not even be present for the backup to occur. Backups may be automatically scheduled for off-peak computer times to maximize NSG resources.

Database recovery has also been made rapid and straightforward. The entire database or a portion thereof can be restored from a local disk or remote server using the same set of tools. The Enterprise Manager further allows the DBA to specify versions of the database to facilitate good accounting practices.

For the NSG EIS, back up should be conducted locally daily. Portable magnetic media should be checked to ensure the database has written properly, removed, and stored for safekeeping. Periodically, this data should be written to permanent storage such as a CD or Write Once Read Many (WORM) disk. WORM media cannot be altered and are good tools for permanent archive.

In addition, the database should be backed up remotely to protect against catastrophic failures. The NSG headquarters has already identified one stateside command element whose primary responsibility is archival of NSG historical data. If the

NSG EIS were to be implemented, remote backup to this site should be conducted at a minimum on a weekly basis.

VIII. CONCLUSIONS

A. SYNOPSIS

According to best estimates, the volume of information in the world doubles every 18 months [Ref. 17]. Many Fortune 500 companies have retooled to take advantage of advances in computer technology and networking to foster growth and optimize resources [Ref. 18]. The ability to bring accurate and timely information to bear has become a cornerstone of 21st century military operations as well.

The NSG must follow suit. The NSG has an abundance of data stored in disassociated systems. Extensive overhead forces management to spend excessive time and resources transforming data into useful information.

The proposed EIS outlined in this thesis allows all NSG units instant data access from anywhere. Any drawbacks to the system (more planning is required to implement an EIS securely and specialized configurations may be needed to optimize its performance) are far outweighed by its advantages. The benefits of immediate, global access at low cost justify the extra effort.

This thesis has shown that it is possible to implement an Enterprise Information System affordably and efficiently within the NSG. Doing so would optimize personnel efficiency, maximize data accuracy and timeliness, and reduce costs. An EIS would enhance the Naval Security Group's aggressive pursuit of information dominance.

B. AREAS FOR FURTHER RESEARCH

The purpose of this thesis research is to prove the feasibility of the NSG EIS. The associated sample site reflects only the most basic application of this thesis material. There are many areas of future research associated with this project.

1. Automatic Data Update

Much redundancy exists with the upkeep of military database systems. Just as the NSG headquarters provides guidance to its units, various higher echelon entities of the United States Navy provide guidance to the NSG.

The EIS sample site relies on personnel to manually enter data into the database. Other Navy sites already maintain much of this data. For example, the Navy's Bureau of Personnel, the cognizant authority on Navy manpower, maintains very large databases concerning billets and personnel. A regularly scheduled data subscription to these databases to the NSG EIS would preclude manual data reentry.

Similarly, some shipboard units do not yet have unlimited network access. They generate many of the operational reports used within the NSG operations and training functional group. The sample EIS would rely on shore based personnel to reenter report data into the database. As these reports are transmitted electronically, finding a way to automatically update report data to appropriate database fields would be a worthwhile endeavor.

2. Data Integrity and Security

There are many aspects of information security that have not been examined in detail for this system. Configuring the NT operating system of the sample site in accordance with Ref. 16 must be implemented before the system could be ported to the Internet.

Further, a proxy server could be added to serve as a security firewall. The addition of a proxy server would enhance the security of the system and allow the SA to further protect the main file systems of the server.

The subject of encryption has not been addressed in this research. Link encryption through a more trusted protocol such as secure HTTP would help to strengthen data privacy. Encryption of the data as it resides in the database server would help to preserve both data integrity and privacy. Both measures should be investigated if the NSG EIS is to be implemented on an insecure network such as the Internet.

Finally, it is not mandatory that the system be fielded on the Internet. As previously stated in the introduction section, most NSG units subscribe to more secure networks. An investigation in how to migrate this system to a more secure network would better protect existing unclassified data and possibly allow for the limited processing of some classified data.

3. Functional Expansion

The existing EIS is far from complete in its functionality. The expansion of its capabilities to include additional NSG operations would be important. Notably missing from the current system are fixed site operational data, additional personnel information, and safety information.

In addition, all implemented functional groups could be greatly expanded to provide extended information to community managers. Additional queries to include such benchmarks as manning ratios and deployment ratios would be beneficial to NSG management.

Finally, the design of this system was limited in scope to units of the Naval Security Group. Other non-NSG units should also benefit from an EIS.

4. Increase User-Friendliness

SQL Server 6.5 generates and displays error messages specific to the miscue. These messages are cryptic and difficult for even the database designer to understand. The database software contains tools to tailor own error messages to instruct the user as to what error has occurred and what steps are needed in order to correct it. Creating a bank of such exceptions would increase the usability of the system.

In addition, the interface could be expanded to include features that improve both usability and flexibility. Some interface construction software such as JavaScript contain additional features that could be added to data entry forms and web pages without sacrificing interoperability. Retooling the interface using such devices would make the system more flexible and better accommodate naïve and experienced users alike.

Navigation of the system is fairly straightforward but could be greatly enhanced with on-line help. Implementing a set of help services would aid the user as to what entries were appropriate for certain web pages and help guide the user through a desired data operation. Users who are not familiar with data keeping operations, NSG procedures, or web browsers could be readily walked through the site with a good tutorial.

Finally, all data at the sample site is returned in text format. While exact, this is not always the best method for presenting data to a user. Much analysis, especially temporal analysis, is often better conducted using graphical tools. Devising a way to return some data sets in graphical form would greatly enhance the system.

5. Intelligent Processes

The sample site EIS requires managerial personnel to periodically monitor the database and perform limited analysis on data returned from queries. To augment these efforts, a series of intelligent processes should be created to automatically alert supervisory personnel that certain data points have been reached that are contrary to preset tolerances. The concept of a manager getting email from the EIS specifying that a command has fallen below a minimal manning level or that a person is approaching the flight hour limit for the month is not far-fetched.

6. Optimization

Only about five megabytes of data are currently present within the database. No effort has been made to minimize memory space. Varchar and text data types have been maximized to provide the most flexibility for the designer. An actual NSG EIS would be populated with data from approximately 11,000 people and numerous commands. Without careful table and field management, one could quickly utilize all available disk space to store data.

Many queries perform a required calculation on the spot, return the result to the user and then discard the data. The result is recalculated the next time the query is called. Any query, particularly a mathematical calculation, that is submitted to a heavily populated database can sort through hundreds of megabytes before the correct combination of data sets is recognized, retrieved and returned. This translates to lost time on the part of the user. A thorough examination of system performance, including testing with large sets of data and storage of intermediate query results, would be necessary before the EIS could be realistically implemented.

In addition, the implemented NSG EIS would allow hundreds of people to concurrently perform data updates and queries. To handle large numbers of simultaneous connections, configuration optimization would need to be examined. Due to budgetary constraints, the sample site places the file system, the web server, and the database server all reside on the same machine. Separating these would allow the database administrator to optimize each to peak performance.

7. Upgrades

At the time of this writing, IIS 4.0 has been fielded and SQL Server 7.0 is completing Beta testing. The finalized versions of both would be available at no cost to Microsoft Development Network Subscribers. Documentation on additional software capabilities and improvements are unavailable. Upgrading the sample site to the newer versions should result in improvements in capacity, functionality, and performance.

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APPENDIX A. ABBREVIATIONS

ACL - Access Control List

COTS - Commercial-Off-the-Shelf

DBA - Database Administrator

DBMS - Database Management System

DoD - Department of Defense

DoN - Department of the Navy

EAOS - End of Active Obligated Service

EIS - Enterprise Information System

FTP - File Transfer Protocol

HTM - Hypertext Markup File

HTML - Hypertext Markup Language

HTTP - Hypertext Transfer Protocol

HTX - Hypertext Markup Template

IDC - Internet Database Connector

IIS - Internet Information Server

IP - Internet Protocol

LAN - Local Area Network

NEC - Navy Enlisted Classification code

NPS - Naval Postgraduate School

NSG - Naval Security Group

ODBC - Open Database Connectivity

PMS - Preventative Maintenance System

PRT - Physical Readiness Test

SA - System Administrator

SQL - Standard Query Language

TAD - Temporary Assigned Duty

UIC - Unit Identification Code

URL - Universal Resource Locator

WORM - Write Once, Read Many

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APPENDIX C. SAMPLE CODE

A. HTM FILE - COMMAND GROUP MAIN PAGE

The sample site Command Group main page is shown below. The data operations accessible to this page are displayed as underlined hyperlink selections.



Insert Data

Add New Division
Add New Department
Sailor Check-In
at Command

Change Data

Command Structure

Change Department
Information

Change Division
Information

Sailor

Reenlist Sailor
Transfer Sailor

Query Database

Billets

Billets Filled
Billet Structure

Budget Balances

Annual Balance Report
Quarterly Balance Report

Chain of Command
Command Structure
Emergency Recall List

Command Demographics

Gender
NEC
Rank
Rate

Miscellaneous

Binnacle List Statistics
PRT Report
Retention Statistics
Roster
Upcoming Reenlistments

Operations

Days at Sea Flight Hours
TAD Report By Mission
 Totals

B. HTM FILE - PRT REPORT QUERY (FORM)

The sample site Command Group PRT query is shown below as an example of HTM format. The form has been displayed in graphic form vice HTML format to preserve clarity.

Command PRT Statistics

Please enter query information:

Please choose the command, the PRT score category and the timeframe desired to display a command's PRT statistics.

	<div>NSGA Alpha</div>
	<div><div><div></div></div> Outstanding</div>
	<div><div><div></div></div> Excellent</div>
	<div><div><div></div></div> Good</div>
	<div><div><div></div></div> Satisfactory</div>
	<div><div><div></div></div> Fail</div>
Start Date	<div>1/1/97</div>
Stop Date	<div>1/1/98</div>
	<div><div>Submit Query</div><div>Reset Form</div></div>

C. IDC FILE - SQL CODE FOR PRT QUERY

The corresponding sample site PRT query IDC file is displayed below as an example of a SQL statement.

```
DATASOURCE: NSGDB SQL
USERNAME: SA
TEMPLATE: PRTCOM.HTX
SQLSTATEMENT:
+SELECT  SAILOR.RANK_RATE,
+        SAILOR.FIRSTNAME,
+        SAILOR.LASTNAME,
+        SAILOR.SEX,
+        PRT_DATA.COMMAND_ID,
+        PRT_DATA.PRT_IDENTIFIER,
+        PRT_DATA.SOCIAL_SECURITY_NUMBER,
+        PRT_DATA.HEIGHT,
+        PRT_DATA.WEIGHT,
+        PRT_DATA.PUSHUPS,
+        PRT_DATA.SITUPS,
+        PRT_DATA.RUN_TIME,
+        CONVERT (CHAR(12), PRT_DATA.PRT_DATE, 107) AS DATEX,
+        PRT_DATA.STATUS,
+        COMMAND_INFORMATION.COMMAND_NAME
+ FROM    SAILOR INNER JOIN PRT_DATA INNER JOIN COMMAND_INFORMATION ON
+        PRT_DATA.COMMAND_ID = COMMAND_INFORMATION.COMMAND_ID ON
+        SAILOR.SOCIAL_SECURITY_NUMBER = PRT_DATA.SOCIAL_SECURITY_NUMBER
+ WHERE   (PRT_DATA.COMMAND_ID = '%COMMAND_ID%') AND
+        (PRT_DATA.STATUS = '%STATUS1%' OR
+        PRT_DATA.STATUS = '%STATUS2%' OR
+        PRT_DATA.STATUS = '%STATUS3%' OR
+        PRT_DATA.STATUS = '%STATUS4%' OR
+        PRT_DATA.STATUS = '%STATUS5%') AND
+        (PRT_DATA.PRT_DATE >= '%START_DATE%' AND
+        PRT_DATA.PRT_DATE < '%STOP_DATE%')
+ ORDER BY PRT_DATA.STATUS,
+         SAILOR.LASTNAME,
+         PRT_DATA.PRT_DATE
```

D. HTX FILE - RESULTS FORM

The HTX file referenced by the above IDC file is displayed below to demonstrate the HTX format. Fields enclosed by the "<% %>" symbol represent database objects returned by the database engine from the corresponding SQL query. If no results are returned from the query, the default statement at the base of the file will be displayed.

Command PRT Results

Rank/ Rate	First Name	Last Name	Sex	Date	Height	Weight	Pushups	Situps	Run Time	Score
<% Rank_ Rate	<% First Name %>	<% Last Name %>	<% Sex %>	<% date %>	<% Height %>	<% Weight %>	<% Pushups %>	<% Situps %>	<% Run_ Time %>	<% Status %>

Sorry. No records match.

E. HTX FILE - RETURNED QUERY RESULTS

The sample site data set returned from the query contained in the form shown in Appendix C Part B is shown below.

Command PRT Results *NSGA Alpha*

Rank/Rate	First Name	Last Name	Sex	Date	Height	Weight	Pushups	Situps	Run Time	Score
CTO1	Natalie	Amsterdam	F	Feb 05, 1997	64	145	30	35	15:15	F
CTO2	Arnold	Bonn	M	Aug 01, 1997	68	145	35	35	14:05	F
CTT2	Ralph	Dakota	M	Aug 01, 1997	74	170	45	60	13:45	F
CTISN	Sarah	Fir	F	Aug 01, 1997	69	160	40	32	14:45	F
CTRC	Cassandra	Granite	F	Feb 05, 1997	68	155	15	30	14:55	F
CTRC	Cassandra	Granite	F	Aug 01, 1997	68	151	15	29	14:40	F
LTJG	Sarah	Slate	F	Aug 01, 1997	63	143	22	45	14:00	F
CTM3	Cheyenne	Windstar	F	Aug 01, 1997	65	130	50	65	14:49	F
LT	Kevin	Beige	M	Feb 05, 1997	74	140	67	100	9:55	O
CTASN	Kyle	Dumas	M	Feb 05, 1997	67	140	67	65	9:35	O
CTASN	Kyle	Dumas	M	Aug 01, 1997	67	135	67	80	9:33	O
CTMC	Rosemary	Edsel	F	Aug 01, 1997	70	144	45	80	12:44	O
LT	Elijah	Gray	M	Aug 01, 1997	66	137	55	77	12:19	O
ENS	April	Gris	F	Feb 05, 1997	69	135	50	100	09:55	O
CTA3	Perry	King	M	Aug 01, 1997	71	195	67	100	13:40	O
CTM3	Wally	Nova	M	Feb 05, 1997	67	160	67	100	09:09	O
CTM3	Wally	Nova	M	Aug 01, 1997	67	155	67	100	09:15	O
CTR2	Boris	Quartz	M	Feb 05, 1997	74	205	67	100	09:56	O
CTA2	Tory	Shelley	F	Aug 01, 1997	64	129	60	100	9:55	O
CTO2	Alice	Stratford	F	Feb 05, 1997	64	120	55	100	09:20	O

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